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[NOVEMBER, 1893.]

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Mineralogical Society.

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EDITED BY H. A. MIERS, M.A.,

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REPORT.

The Balance Sheet for the year ending December 31st, 1892, which was issued with Number 46 of the Journal, showed that the state of the finances was not unsatisfactory: the Assets (exclusive of the Stock of the Journal and Library) amounting to 274 15s. 7d. The number of existing Members who had compounded before December 31st, 1892, for their Annual Subscription was thirty-three.

During the session 1892-3 two Ordinary Members have been elected, one Member has resigned, two non-effective Members have been removed for non-payment of Subscriptions, and one Member, Mr. Thomas Davies, has died.

The death of Mr. Davies, of whom an obituary appeared in Number 46 of the Journal, having caused an interim vacancy in the Foreign-Secretaryship, Professor Judd was elected to that office: further, Professor Macadam was elected to the Ordinary Membership of Council vacated by Professor Judd, thus increasing the Scotch representation.

Four Meetings have been held during the year, all in London, and (by kind permission) in the Apartments of the Geological Society, Burlington House.

Only one Number of the Journal has been issued since the last Anniversary Meeting, but the number of pages, 105, is larger than the average. To this Number Lieut.-General McMahon contributed a detailed account of his microscopic observations on a long series of sulphates: Professor Judd followed with a remarkable paper relative to the lamellar structure of Quartz-crystals and the methods by which it is developed: Professor Grenville Cole gave an account of some examples of Cone-in-Cone structure; Professor Lewis a note on the occurrence of a rare form of tourmaline crystal; Mr. Stuart Thomson a description of an occurrence of isolated crystals of galena in sandstone: Mr. Dick and Mr. Fletcher, respectively, described two new minerals from Ceylon, Geikielite and Baddeleyite, both of noteworthy composition; the former being a titanate of magnesium, the latter native zirconia. The contributions of those

Members who have volunteered to prepare abstracts of important mineralogical memoirs published elsewhere have added considerably to the utility and interest of the Number. The Society is indebted to the generosity of Lieutenant-General McMahon and Professor Judd for the excellent plates which are a feature of the Number.

The Council considered it desirable to initiate a "Thomas Davies Memorial Fund" for the benefit of the widow and children of the late Foreign Secretary and former Editor of the Journal. Friends, both far and near, have readily availed themselves of the opportunity thus afforded of paying a tribute to his memory, and the Fund has now reached a total of £480.

On the motion of the Chairman, seconded by Mr. J. H. Collins, the Report of Council was adopted.

Lieut.-General McMahon and Mr. Rutley having been nominated to act as the Scrutineers, reported that 36 voting papers had been returned to the Secretary, and that the following list of Officers and Council was unanimously approved :—

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A vote of thanks to the auditors (Mr. Kitto and Mr. Rutley) was passed, and the auditors were re-elected.

Votes of thanks were also passed to the retiring Members of Council Prof. Grenville Cole, Mr. Danby, Mr. Horne and Mr. Rutley), to the Editor of the Journal, and to the Geological Society for the use of its apartments.

The following papers were then read:—

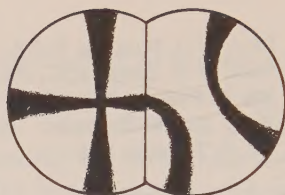
1. On a meteoric stone which fell near Jafferabad, India, on April 38th, 1893: by Professor Judd, Foreign Secretary.
2. On the "skin" of agates: by Professor M. F. Heddle and Mr. S. Thomson. (Page 248).
3. Notes on a Zircon from Expailly, Haute-Loire: by Mr. Rutley.
4. On Spangolite: by Mr. Miers.
5. On Fulgurites: by Mr. Rutley.

Specimens were exhibited in illustration of their papers by Professor Judd, Mr. Rutley and Mr. Miers.

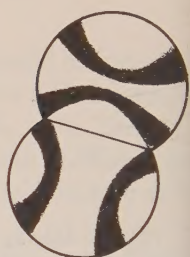
Mr. A. L. Collins exhibited an excellent crystal of gadolinite from Moss, in Norway, and a fine specimen of spinel from Afghanistan.



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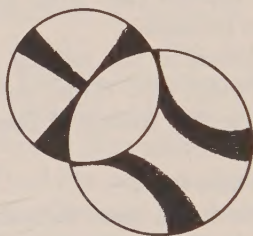
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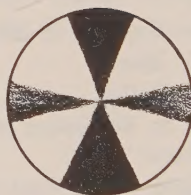
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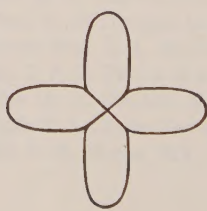
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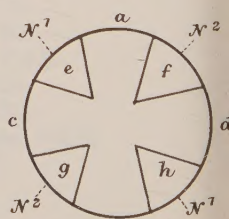
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THE MINERALOGICAL MAGAZINE
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NOVEMBER, 1893.

Vol. X.

Xanthoconite and Pittingerite, with remarks on the Red Silvers.

By H. A. MIERS, M.A., F.G.S.,

With analyses by G. T. PRIOR, M.A.

[Read January 17th, 1893.]

Literature relating to Xanthoconite and Pittingerite.

1. 1840. Breithaupt, *Journal für praktische Chemie*, XX., 67.
2. 1845. Breithaupt, *Poggendorf, Annalen*, LXIV., 272.
3. 1845. Plattner ,, ,, ,, 275.
4. 1852. Zippe, *Sitzungsberichte Akad. Wien*, IX., 345.
5. 1866. Weisbach, *Berg-und Hütten-männische Zeitung*, XXV., 54.
6. 1872. Schrauf, *Sitzungsberichte Akad. Wien*, LXV., 227.
7. 1874. Frenzel, *Mineralogisches Lexicon Sachsen*, 348.
8. 1878. Streng, *Neues Jahrbuch*, 917.
9. 1879. Schrauf, ,, ,, 144.
10. 1879. Streng, ,, ,, 547.
11. 1879. Becke, *Tschermak, Mineralogische Mittheilungen*, II., 94.
12. 1886. Streng, *Neues Jahrbuch* (1), 57.

CONTENTS.

- I. Historical sketch. (*A*) Xanthoconite. (*B*) Rittingerite.
- II. Summary of results.
- III. Description of Xanthoconite. (*a*) Modes of occurrence and association. (*b*) Crystalline form. (*c*) Hardness. (*d*) Colour. (*e*) Streak. (*f*) Lustre. (*g*) Optical characters. (*h*) Chemical characters.
- IV. Description of Rittingerite, do. do.
- V. Identity of Xanthoconite and Rittingerite.
- VI. The Family of the Red Silvers.

I. HISTORICAL SKETCH.

(*A*). *Xanthoconite*.—The name xanthoconite was given by Breithaupt (1) to a mineral which he found in 1840 associated with proustite upon an old ore-specimen in the collection of the Berg-Akademie at Freiberg. He describes it as occurring in reniform masses with a surface consisting of microscopic crystals, but with a crystalline granular interior. The crystals appeared to be either acute rhombohedra or a combination of a rhombohedron with a hemidome; $H = 2-3$; Sp. Gr. = $4.112-4.159$. Plattner could find only silver, arsenic and sulphur, with a minute trace of iron; the silver assay gave 59.1 per cent. This specimen was from the Himmelsfürst mine at Erbsdorf, near Freiberg, and was raised in 1797.

Five years later in the same mine Breithaupt himself (2) found another variety of the mineral occurring in thin tabular crystals in calcite. Only one specimen was found. The measurement of the broken fragments of an apparently hexagonal plate led him to the conclusion that the crystals were a combination of the basal plane with two rhombs, having the even cleavage parallel to one of the rhombohedrons and to the basal plane; $H = 2\frac{1}{2}-3\frac{1}{4}$; Sp. Gr. = $5.078-5.166$; a new determination of the material originally described, after it had been carefully purified from intermixed "Silberschwärze," gave Sp. Gr. = $5.158-5.191$.

These two varieties of xanthoconite are distinguished by a difference of colour; the original mineral was dark cochineal-red to clove-brown in mass, and orange-yellow in the thinnest crystals, with a glistening streak of a dark orange-yellow inclined to yellowish-brown colour; the second specimen was orange-yellow, with a streak between orange-yellow and yellowish-brown, somewhat darker than the superficial colour.

Analyses of both these specimens were made by Plattner (3), who found for the brown variety (using 0.5 gram)

$$\text{Ag} = 64.181$$

$$\text{S} = 21.358$$

$$\text{Fe} = 0.970$$

ence by difference $\text{As} = 13.491$). An independent assay gave 64.2 per cent. of silver.

Of the yellow variety there was only sufficient material for the determination of the sulphur in the wet way, the silver being estimated by the blowpipe. The numbers obtained were:—

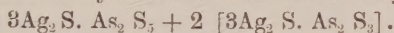
$$\text{Ag} = 63.880$$

$$\text{S} = 21.798$$

ence by difference $\text{As} = 14.322$).

This variety contained no iron.

The formula deduced by Plattner from these analyses is



Xanthoconite was thus made to represent a new type in mineralogy, no *arsenate* having been previously described.

Twenty-one years later Weisbach (5) mentions the further occurrence of this very rare mineral at the Himmelfahrt mine in 1860, and at the Pegneter Bergmanns Hoffnung mine in 1864. One interesting observation of this author seems to have escaped the notice which it deserved: he found an isolated crystal on one of the specimens having the appearance of a rhombic prism combined with a hemidome, and suggested that xanthoconite may be in reality a hemi-rhombic mineral.

Frenzel (7) mentions other mines in the Freiberg district which have yielded xanthoconite.

(8). *Rittingerite*. This mineral was first described by Zippe (4) in 1822, as occurring in minute crystals with proustite from Eliaszeche near Joachimsthal.

Delabuss, who measured the crystals, found them to be rhombic-shaped crystals belonging to the monosymmetric system, the plane of symmetry being parallel to the shorter diagonal (see fig. 5); there was a cleavage parallel to the plane of the plates; $H = 2\frac{1}{2} - 3$; lustre metallic-adamantine; colour dark honey-yellow inclined to hyacinth-red; streak orange-brown. The material was insufficient for analysis, but blowpipe tests proved the presence of silver and arsenic.

Zippe remarks that the mineral differs from proustite in colour and luster, and suggests that it has a different chemical composition, but that it may bear the same relation to fireblende that proustite does to pyrrhotite; he distinguishes it from xanthoconite on account of the crystalline form, colour and inferior transparency.

Twenty years later Schrauf published an elaborate memoir on similar crystals from Joachimsthal, dispersed on the pseudomorphous sulphides described by Tschermak under the name "Silberkies" (*Sitzungsber. Akad. Wien*, LIV. (1) 342).

With material weighing 0.0045 gram Schrauf determined the specific gravity to be 5.63, and the percentage of silver (by reduction with charcoal) to be 57.7. Besides the silver he found arsenic, but failing to obtain any clear indications of sulphur, and thinking that he recognised the characteristic smell of selenium when the mineral was heated, concluded that rittingerite is a compound of silver, arsenic and selenium.

This author's crystallographic observations, which lead to results differing somewhat from those of Schabus, will be discussed below. It is sufficient to say here, that the plane angle of the rhombic plates (which should be $126^{\circ}18'$ according to Schabus) was determined by Schrauf to be $124^{\circ}20'$ by means of microscopic measurements.

Streng (8) in 1878, described as fireblende some small crystals with the habit of stilbite and of a hyacinth-red colour occurring upon pyrite, and associated with proustite, from the Dolores I. mine, Chañarcillo.

Schrauf (9), however, in the following year pointed out that Streng's measurements agreed very closely with his own measurements of rittingerite, and suggested that the Chañarcillo mineral should be referred to that species.

Streng (10) confessed that the angles were the same, but pointed out that there is a striking similarity between certain angles in rittingerite, xanthoconite and fireblende. He found by blowpipe tests that the Chañarcillo mineral contained sulphur and silver, and therefore concluded that it could not be identical with Schrauf's rittingerite, which contained selenium and no sulphur.

Seven years later, however, Streng (12) proved by micro-chemical actions, both in the Chañarcillo mineral and in the rittingerite from Joachimsthal, the presence of silver, arsenic and sulphur, and failed to recognise selenium in either.

Becke (11) had previously, in 1879, noted the occurrence, at Schmitz, of minerals which he describes as rittingerite and fireblende, and stated that the latter yielded silver and arsenic (!).

II. SUMMARY OF RESULTS.

From the above survey xanthoconite and rittingerite appear to be two fairly well defined species, and accordingly we find them so described in the text-books.

Xanthoconite is stated to be a sulph-arsenate, containing about 64 per cent. of silver, having a specific gravity about 5·2, and crystallising in the rhombohedral system.

Rittingerite is generally regarded as a compound of silver, arsenic and selenium, containing about 58 per cent. of silver, having a specific gravity about 5·6, and crystallising in rhombic tables belonging to the monosymmetric system.

On the other hand, when the data are criticised more closely it is seen that, as regards xanthoconite, some doubt is thrown upon the crystalline form by the observation of Weisbach, while in the case of rittingerite the composition is left uncertain owing to the micro-chemical examination of Freng. It will appear in the course of the following investigation that neither of these minerals has yet been correctly determined in respect of composition, form or physical characters.

Now it is only necessary to examine the two minerals under the microscope to see that they are remarkably similar in most respects.

In the following pages it will be shown that xanthoconite and rittingerite are one and the same mineral; that this mineral has the percentage composition of proustite, but differs completely from that species in physical and morphological characters; and that it is isomorphous with fireblende, and bears the same relation to proustite which fireblende bears to pyrargyrite.

The observations will be described in considerable detail, for the material is not all that could be desired for accurate measurement and analysis: consequently we have to show in the first place that the characters of the two minerals, even if only approximately determined, are identical within the limits of error, and then, by combining the best from all the observations made on both varieties, to deduce the best possible constants for the species.

III. DESCRIPTION OF XANTHOCONITE.

a.) *Modes of occurrence and associations.*—The collection of the British Museum contains about thirty specimens of this mineral from the following localities: Freiberg, Johanngeorgenstadt, Markirsch, Rudelstadt and Chañarcillo.

The majority of the specimens from Freiberg were acquired recently for the purpose of the present investigation.

The xanthoconite from these localities presents such differences of appearance that a short description of each is necessary.

Freiberg.—Among the specimens in the British Museum there is nothing which resembles the reniform crystalline-granular and brownish material described by Breithaupt and analysed by Plattner; they all agree more nearly with that described by Breithaupt in 1845, as yellow tabular crystals occurring in calcite. Among these, at least three types are to be distinguished.

(1.) Small round masses, consisting of an aggregation of minute orange-yellow tablets, like fig. 3.

(2.) Stout tabular crystals with striated sides, somewhat resembling hexagonal plates with bevelled edges like those of the tabular Freiberg stephanite; these are always composed of irregularly grouped plates intergrown in nearly parallel positions; fig. 3.

(3.) Isolated thin plates resembling fireblende in habit, see figs. 1, 2.

The colour of all these crystals is usually a dull orange to brownish yellow, but on some specimens of the second and third types they are a rich vermilion-red very nearly identical with that of proustite.

In thin splinters all exhibit the same lemon-yellow colour by transmitted light, and the streak is the same:—clear orange-yellow for all.

One specimen which appears to be identical with the remainder is labelled as from Siebenlehn, Nassau-Freiberg. On the Freiberg specimen the xanthoconite is sparsely dispersed upon calcite, together with brilliant scalenohedral crystals of proustite; the specimens occasionally show decomposing marcasite somewhat resembling the silberkies with which rittingerite is associated at Joachimsthal; also stephanite, argentite and the decomposition products of cobalt and nickel ores.

The xanthoconite itself is always situated in isolated crystals or groups upon the calcite, sometimes also in the form of very thin scales filling cavities in the calcite; it is contemporaneous with the proustite, and we have never observed the paragenesis mentioned by Breithaupt, who speaks of proustite occurring upon xanthoconite.

One specimen alone differs somewhat from the others; the xanthoconite here occurring in irregular rhombic tables upon the corroded surface of crystallised argentite.

Johanngeorgenstadt.—One specimen from this locality shows xanthoconite in rhombic plates, having a habit like that of the Joachimsthal rittingerite, of a brownish-yellow colour, dispersed on vein-quartz with proustite, argentopyrite (in small crystals) and a little calcite.

Rudelstadt.—Two specimens from this locality present the mineral in a yellow-brown earthy form disseminated in calcite which veins masses of arsenic.

Markirch, Elsass.—This occurrence has not been previously described. The crystals were noticed by myself in the recesses of a fine specimen of proustite where they were almost concealed by other minerals.

The xanthoconite occurs in brilliant striated orange-yellow crystals whose projecting corners somewhat resemble rhombohedra of chalybite; they are situated on pearlspar and are accompanied by fine prisms of proustite and crystallised calcite, overlying botryoidal arsenic; here again the mineral appears to be contemporaneous with the proustite.

I have noticed xanthoconite from this locality in the Berlin Museum of Mineralogische Naturkunde, and other examples will doubtless be found if search be made among the older specimens of proustite from Markirch (Sainte Marie-aux-Mines).

The habit of the crystals is quite peculiar, see fig. 2. p. 194, and they are much larger than those from Freiberg. It will be seen below that these crystals are all-important as establishing the symmetry of the mineral.

Chañarcillo, Chili.—The crystals from this locality appear to be of the same habit as the Markirch xanthoconite. They are stout orange-yellow composite crystals occurring with prisms of proustite upon crystallised calcite. A beautiful specimen was acquired by the British Museum in 1861; I have found a magnificent crystal of the same habit, no less than 10 mm. in diameter, in a cavity between crystals of calcite on a specimen of proustite from the mine Dolores I. This crystal could only be made nearly visible by removing one side of the specimen. The mineral examined by Streng was from the same mine, and there is not the least doubt that it was xanthoconite.

(b). *Crystalline Form.*—This is generally supposed to have been determined by Breithaupt, but in reality his measurements only relate to a tabular crystal which broke to pieces in his fingers, so that he was only able to measure fragments; moreover, the reflecting surfaces were so bad that he was compelled to use the sun as a distant signal, and he expressly states that the angles cannot be relied upon to less than a degree. Such determination is obviously almost valueless. It is difficult to understand how Breithaupt ever imagined the crystals to be hexagonal; they generally rather resemble rhombic tables or are thin plates like those of fireblende. Weissbach, as we have seen, suggested that the mineral may be really semi-rhombic. The optical characters are sufficient to show at a glance that it cannot be hexagonal.

The measurements of Streng will be discussed below. The measurements which I have been able to make relate to ten crystals from Freiberg,

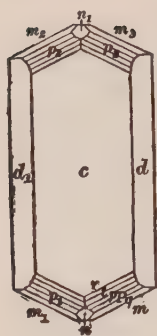


Fig. 1.

and two from Markirch. All the best readings are given in the following table, and all the faces indicated by definite reflections, whether good or bad, are mentioned. The letters refer to fig. 1, which gives a general survey of the crystals; they are *all* fragments, and are supposed to be orientated as in fig. 1; p' is parallel to p , p_1' to p_1 &c.; a is a face nearly perpendicular to c on the right of the figure.

No account is here taken of a vast number of imperfect or striated faces which yielded indefinite or banded images. Those readings which are really excellent are marked with an asterisk.

- Crystal 1.** Determinable faces, $c p t d a a' c' d' d_1' n_1' q_3'$
 $ac = 90^\circ 20'$ $ct = 36^\circ 46'$
 $c'q_3' = 80^\circ 46'$ $cn_1' = 119^\circ 51'$
- Crystal 2.** Determinable faces, $c c' t p_1 n_1'$
 $c' n_1' = 59^\circ 52'$ or $60^\circ 20'$.
- Crystal 3.** Determinable faces, $c p d c' d_1' q_2'$
 $cd = 69^\circ 12'$ to $69^\circ 33'$ $cq_2' = 100^\circ 26'$
 $cp = 41^\circ 11'$.
- Crystal 4.** Determinable faces, $c a m m_1 c' d_1' p_3'$
 $c' d_1' = 69^\circ 29'$ $* a m = 62^\circ 28'$
 $c' m = 90^\circ 35'$ $* m m_1 = 55^\circ 7'$
 $* cm_1 = 90^\circ 8'$.
- Crystal 5.** Determinable faces, $c t P d c' p_2' d_1'$
 $cP = 49^\circ 31'$
 $Pd_1' = 85^\circ 19'$
 $c' d_1' = 69^\circ 24'$.
- Crystal 6.** Determinable faces, $c m$ (2 faces $m_\alpha m_\beta$) $m_1 d n_3' c' p_3'$
 $cm_\alpha = 89^\circ 55'$ $cm_1 = 86^\circ 38'$ $c' d = 109^\circ 46'$
 $c' m_\beta = 89^\circ 24'$ $* mm_1 = 55^\circ 8'$.
- Crystal 7.** Determinable faces, $c d q_2 q_3$
 $cq_3 = 79^\circ 3'$ or $79^\circ 59'$
 $cd = 69^\circ 15'$ or $69^\circ 57'$
 $* dq_3 = 61^\circ 2'$.
- Crystal 8.** Determinable faces, $c a m P r_1 p_1 d_1 c' d_1' t_2' p_2' n_1'$
 $cd_1' = 70^\circ 46'$
 $c' a = 90^\circ 22'$
 $am = 62^\circ 32'$.

Crystal 9. Determinable faces, $c d d_1'$

$$cd = 68^\circ 42'$$

$$d d_1' = 41^\circ 22'$$

Crystal 10. Determinable faces, $c q$

$$cq = 77^\circ 1'$$

From the above measurements it is clear that the xanthoconite from Freiberg is not hexagonal, but is either orthorhombic or monosymmetric; the crystals are not sufficiently perfect to disclose the symmetry by their regular relations alone, but the optical characters show them to be monosymmetric since a bisectrix emerges nearly normal to c , but slightly inclined thereto in the plane containing the normals of $c a d$. Further, the optical characters show the plates to consist of twinned crystals which overlap. This twinning accounts for the appearance of the orthorhombic d at both the upper and lower ends of crystals 1, 3, 5, 9.

The axial angle ac may be calculated from the very perfect measurements, $cm = 90^\circ 8'$ and $am = 62^\circ 28'$, of crystal 4, which give $ac = 89^\circ 42\frac{1}{4}'$, showing that xanthoconite may be referred to three very nearly rectangular axes.

Now, owing partly to the twinning and partly to the imperfections of the faces on these crystals, it is impossible to say whether the various pyramids lie within the acute or the obtuse axial angles, so that we are compelled as a first approximation to take the axes as rectangular.

The angles and indices are then as follows:—

a 100	q 551	h 334
c 001	d 501	n 053
m 110	t 223	
P 111	r 112	

$$a : b : c = 1.921 : 1 : 1.034$$

$$\beta = 90^\circ 0'$$

		Observed.	Limits.	No.	Calculated.
$a m$	100 : 110	$62^\circ 30'$	$62^\circ 28' - 62^\circ 32'$	2	$^\circ - '$
$m m$	100 : $\bar{1}10$	$55^\circ 5'$	$55^\circ 3' - 55^\circ 7'$	2	$55^\circ 0'$
$c d$	001 : 501	$69^\circ 37'$	$68^\circ 42' - 70^\circ 46'$	9	—
$c h$	001 : 334	$41^\circ 11'$		1	$41^\circ 9'$
$c t$	001 : 223	$36^\circ 46'$		1	$37^\circ 51'$
$c P$	001 : 111	$49^\circ 31'$		1	$49^\circ 22\frac{1}{2}'$
$e q$	001 : 551	$79^\circ 17'$	$77^\circ 1' - 80^\circ 46'$	5	$80^\circ 16'$
$c a$	001 : 100	$90^\circ 21'$	$90^\circ 20' - 90^\circ 22'$	2	$90^\circ 0'$
$c m$	001 : 110	$90^\circ 0'$	$89^\circ 24' - 90^\circ 35'$	4	$90^\circ 0'$
$c n$	001 : 053	$60^\circ 4'$	$59^\circ 52' - 60^\circ 20'$	3	$59^\circ 52\frac{1}{2}'$
$P d$	111 : $50\bar{1}$	$85^\circ 19'$		1	$84^\circ 10\frac{1}{2}'$
$d q$	501 : 551	$61^\circ 2'$		1	$60^\circ 57'$
$d d$	501 : $50\bar{1}$	$41^\circ 22'$		1	$40^\circ 46'$

The correct interpretation of these measurements is to be found in the table of calculated angles on p. 212.

It is clear that the two angles measured by Breithaupt, namely $69^{\circ}36'$ and $79^{\circ}25'$, are the angles cd and cq , and that his measurements were very near the truth; a combination of cqd would perhaps somewhat resemble a combination of basal plane with two rhombohedra in a crystal belonging to the second type.

We have now to compare with the above the results obtained from a small group removed from the Markirch specimen; this group consists of two crystals (fig. 2) united in twin position, the faces c c_1 being nearly parallel.

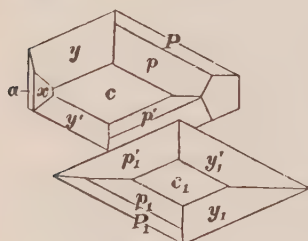


FIG. 2.

$$\begin{aligned} cy &= 57^{\circ}19' \\ cp &= 48^{\circ}27' \\ cP &= 49^{\circ}28' \\ cp' &= 47^{\circ}59' \\ cx &= 74^{\circ}49' \\ ca &= 88^{\circ}37' \\ ca &= 89^{\circ}41' \\ cd &= 70^{\circ}17' \end{aligned}$$

$$\begin{aligned} *c_1y_1 &= 56^{\circ}9' \\ c_1y_1' &= 55^{\circ}55' \\ *c_1p_1 &= 48^{\circ}10' \\ c_1P_1 &= 49^{\circ}17' \\ *c_1p_1' &= 48^{\circ}36' \\ *p_1p_1' &= 88^{\circ}7' \\ p_1y_1 &= 43^{\circ}32' \end{aligned}$$

These measurements evidently belong to the same mineral as the Freiberg crystals, and they supply the indications of geometrical symmetry which are wanting in the latter. The crystals are seen to be referable to an oblique pyramid with a rhombic base of about 55° , and the plane of symmetry is parallel to the longer diagonal of the base; they prove distinctly that the mineral is twinned in such a manner that two crystals are united in reverse position with the c faces nearly parallel; and they show that there are two distinct forms p P inclined to c at angles of about 48° and $49\frac{1}{2}^{\circ}$ respectively; both these faces are present upon the Freiberg crystals.

Referred to axes similar to those employed above, the indices and corresponding angles are—

$$\begin{array}{ll} p & 111 \\ c & 001 \\ P & 21.21.20 \\ a & 100 \end{array} \quad \begin{array}{ll} y & \bar{4}43 \\ d & 501 \\ x & 701 \end{array}$$

$$a : b : c = 1.936 : 1 : 1.003$$

$$\beta = 90^{\circ}0'$$

		Observed.	Limits.	No.	Calculated.
<i>c p</i>	001 : 111	48 18	47 59—48 36	4	° — '
<i>c y</i>	001 : 443	56 3	55 55—56 9	2	56 15
<i>c a</i>	001 : 100	89 41		1	90 0
<i>c d</i>	001 : $\bar{5}01$	70 17		1	68 47
<i>c P</i>	001 : 21.21.20	49 22½	49 17—49 28	2	49 41
<i>p p</i>	111 : $\bar{1}\bar{1}1$	83 7		1	—
<i>p y</i>	111 : 443	43 32		1	43 12
<i>c x</i>	001 : $\bar{7}01$	74 49		1	74 35

The correct interpretation of the measurements is to be found in the table on p. 212.

A remarkable feature about the mineral is that, whereas the Freiberg crystals show the face *P* and other forms which have simple indices when referred to *P* as (111), the Markirch crystals bear forms which can better be referred to *p* as (111).

One is at once led to imagine that the axial angle may really differ from $2PO'$, and that *P* may be the primary pyramid in the positive, *p* in the negative octant. For the present, however, it is sufficient to establish the fact that the minerals from Freiberg and Markirch are identical, and that the axial ratios are nearly 2 : 1 : 1.

With the preceding measurements we may now compare those of Streng upon the mineral from Chañarcillo, which was described by him as fire-opalende, but being a compound of silver, sulphur and arsenic, is in reality xanthoconite.

The accompanying figure shows the form of the crystals measured by Streng, the orientation and lettering being changed so as to be uniform with those here adopted.

In Streng's description *c* is the plane of symmetry 010,

d is 110

r 919

P 515 and there are also faces of *t* 15.2.15

y 414

q 111

m 101

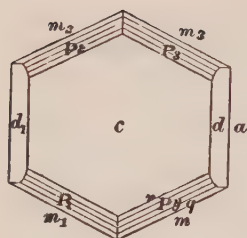


FIG. 3.

$$\begin{aligned} c q &= 81^{\circ}0' \\ *c P &= 49^{\circ}7' \\ *c d &= 69^{\circ}40' \\ *m m &= 55^{\circ}22\frac{1}{2}' \\ P r &= 42^{\circ}2' \\ m m &= 55^{\circ}23' \end{aligned}$$

From the angles $c d$ and $m m$ the axes are calculated as

$$a : b : c = 0.3706 : 1 : 0.1944, \beta = 90^{\circ}0'.$$

With the altered notation the axes will be $a : b : c = 1.906 : 1 : 0.972$, and both as regards form and habit the mineral is identical with xanthoconite.

(c). *Hardness*.—The hardness is, as stated by previous observers between 2 and 3.

(d). *Colour*.—The superficial colour varies from brownish-yellow to vermilion-red, but by transmitted light thin crystals and fragments are always a clear lemon-yellow. The composition of the brown material analysed by Plattner indicates that the colour is probably affected by the presence of iron.

(e). *Streak*.—The streak is always a vivid orange-yellow.

(f). *Lustre*.—The lustre is adamantine; on the face c the lustre is inclined to pearly owing to the cleavage.

(g). *Optical Characters*.—Small tabular crystals of xanthoconite examined under the microscope through the face c show an extinction parallel to the edge $c d$; the double refraction is strong.

The crystals are biaxial with a very large angle; a negative bisectrix emerges nearly perpendicular to c , and the axial plane is parallel to the edge $c d$. By the use of the widest angled condenser and objective available the optic axes are brought within the field of view; dispersion marked, $\rho < v$.



FIG. 4.

When the principal sections of the crystal coincide with those of the nicols, the dark cross of the interference figure is seen to be incomplete, the arm joining the optic axes being absent, while the perpendicular arm is well defined. This is easily explained if we suppose the xanthoconite crystal to consist of two overlapping plates united by the face c ; the plane of symmetry of each is perpendicular to the edge $c d$, the axial plane of each is parallel to the edge $c d$; the bisectrix of each crystal is nearly coincident with the normal to c , but is slightly

inclined thereto in the plane of symmetry, consequently the two plates are so united that their axial planes do not quite coincide although they both have the same plane of symmetry. These results are completely in accordance with the *geometrical* symmetry and twinning of the Markirch crystals; further confirmation is supplied by the appearance of the interference figure when a crystal was rotated about the longer diagonal of the rhomb by means of a stage goniometer constructed for the purpose, so that both optic axes could be brought successively into the field of view; it was then seen that the interference phenomena are due to the overlapping of two nearly coincident biaxial crystals.

With this goniometer it was also possible to measure approximately the axial angle in air; $2E = 125^\circ$ about.

(h). *Chemical Characters.* [G. T. PRIOR.]—The material employed for analysis consisted of a number of small crystals collected from several Freiberg specimens. It was carefully picked out under the lens and microscope so as to free it from intermixed proustite, calcite and iron sulphides, and was finally treated with dilute acetic acid. Only about 25 milligrams were available for analysis. In consideration of the small weight of material it is necessary to give a somewhat detailed account of the methods employed.

The specific gravity determinations were made upon 0.0229 gram by means of a 3 cc. pycnometer, with the following results:—

(1). Weight of xanthoconite in air = 0.0229 gram.

Weight of xanthoconite with water filling the pycnometer at $16^\circ = 3.0262$ grams (mean of 6 determinations varying from 3.0259 to 3.0264).

Weight of water filling the pycnometer at $16^\circ = 3.0075$ gram; spec. grav. = 5.68.

(2). Weight of xanthoconite in air = 0.0227 gram.

Weight of xanthoconite with water filling the pycnometer at $16^\circ = 3.0261$ grams (mean of 9 determinations varying from 3.0258 to 3.0263).

Weight of water filling the pycnometer at $16^\circ = 3.0076$ grams (mean of 4 determinations varying from 3.0078 to 3.0074); spec. grav. = 5.40.

Mean of (1) and (2): spec. grav. = 5.54.

The method of analysis was the same as that employed in the case of pyrrargyrite and proustite (*Min. Mag.* VIII. p. 94). The powdered mineral dried at 100° was transferred to a weighed porcelain boat and decomposed in a current of chlorine. The mineral was readily attacked, even in the cold; the colour changed quickly from orange (between 3 *p* and 4 *m* of Radde's scale) to bright yellow, but on warming it darkened again in parts to a deep red which gradually disappeared as the decom-

position proceeded. The heating was by spirit lamp alone, and was continued until the silver chloride left in the boat just began to fuse. The silver chloride was weighed and then reduced in hydrogen; the silver percentage deduced from the weight of silver obtained was practically identical with that resulting from the weight of chloride.

The purity of the metal was then tested by dissolving in nitric acid, &c.

The chlorides of sulphur and arsenic were absorbed in dilute HCl. The sulphur, which at the commencement of the decomposition was seen to separate on the surface of the liquid in the receiver, was finally all converted into sulphuric acid. After driving off the chlorine and evaporating down at a very gentle heat the sulphur was precipitated by BaCl_2 and, after removal of the excess of the latter reagent, the arsenic was precipitated by H_2S . The sulphide of arsenic was washed with water, alcohol and carbon disulphide, dried and weighed. The sulphur in it was afterwards determined by oxidising with nitric acid and precipitating by BaCl_2 . Both the filtrate and the BaSO_4 precipitate were tested for selenium by means of sulphur dioxide, but with negative results.

The analysis gave the following numbers :—

Weight of xanthoconite used	...	...	0.0253 gram.		
„ „ AgCl	...	0.0219 gr.	...	...	Percentage of Ag=65.15
„ „ BaSO_4	...	0.0351	...	...	„ „ S=19.07
„ „ Sulphide of arsenic	...	0.0070	}	„ „	As=14.63
(Sulphur in this	...	0.0033)			

98.85

The loss of one per cent. is in all probability chiefly due to the escape of traces of arsenic during the evaporations, and in the course of the processes connected with the two precipitations of BaSO_4 .

In order to test the reliability of the above method as applied to such small weights of material, a preliminary analysis was made upon 0.027 gram of proustite. The result as concerned the silver and sulphur was quite satisfactory; the silver percentage obtained was 64.99, and that of the sulphur 19.98, the theoretical values being 65.40 and 19.43; the weight of sulphide of arsenic obtained was 0.0073 gram, which denotes a percentage of arsenic of 13.03 if the sulphide be regarded as As_2S_3 , if, however, the sulphide be considered as a mixture of equal parts of As_2S_3 and As_3S_4 , the number 14.72, which is nearer to 15.17, the theoretical value for proustite, is obtained. If the same supposition be made with regard to the arsenic sulphide precipitate in the case of the xanthoconite, the percentage of arsenic becomes 14.93.

The result of the analysis is therefore

$$\text{Ag} = 65.15$$

$$\text{S} = 19.07$$

$$\text{As} = 14.93$$

$$99.15$$

This analysis shows that xanthoconite has the same percentage composition as proustite; for, although much reliance cannot be placed in the number obtained for the arsenic, yet the results of the comparative analysis of the proustite in the case of the silver and sulphur, and a consideration of the method employed in their determination, inspires confidence as regards the numbers obtained for these constituents in spite of the small weight of material used. First, taking the case of the silver; the chloride is obtained as the residue left in the porcelain boat after decomposition of the mineral in chlorine, and is thus simply weighed in the same vessel in which the mineral was originally placed; accordingly no loss such as is incidental to processes of precipitation, filtration and ignition of precipitates is to be feared. The sulphur determination is not attended with the same advantages, since in this case such processes are necessary; but there is compensation in the fact that the precipitate weighs about ten times as much as the sulphur to be estimated, so that slight losses on that account do not very greatly affect the result.

The only analyses of xanthoconite hitherto published are those of Plattner, and these are open to some criticism.

In his first analysis made upon the brown variety it is true that as much as 0.5 gram seems to have been available, but the arsenic was not directly determined, and nearly one per cent. of iron was found, which is by Plattner himself referred to impurities. The silver percentage was 64.2, and therefore much nearer to 65.4, the theoretical value for proustite, than to 61.4, the percentage required by the sulpharsenate; the same moreover holds good for the sulphur, the percentage 21.36 being nearer to 19.4, the theoretical value for proustite, than to 24.3, that for the sulpharsenate.

If the iron be considered due to the presence of pyrites as impurity, Plattner's numbers become

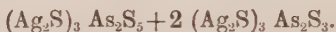
$$\text{Ag} = 65.5 \quad \text{S} = 20.7.$$

The excess of sulphur may be due to the method of analysis, for no mention is made of the removal of the nitric acid after the fusion with potash and sodium carbonate before the precipitation with BaCl_2 .

In the account of the second analysis, made on the yellow variety, the

weight used is not given; but that it was very small is evident from the fact that it was not sufficient to allow of the determination in the wet way, but only by the blowpipe. Breithaupt also speaks of the material as scarcely sufficient for the determination of the specific gravity.

Plattner himself recognised the fact that his numbers were closer to proustite than to the sulpharsenate by giving the somewhat improbable formula



This is the formula which generally appears in works on Mineralogy, but in the last edition of Dana's System its improbability seems to have been recognised, and the mineral is stated to be a sulpharsenate, having the formula



although it would be more logical, if the old formula is to be rejected, to replace it by the formula of proustite.

Altogether it appears that the results of Plattner's analysis cannot be said to oppose the conclusions drawn from the present analysis—that xanthoconite has really the same empirical chemical composition as proustite.

IV. DESCRIPTION OF RITTINGERITE.

(a.) *Modes of occurrence and association.*—The British Museum collection contains 10 specimens corresponding to both the two types described by Schabus and Schrauf. To the former belong those in which the rittingerite occurs in small rhombic tables of a dull yellowish color associated with small scalenohedral crystals of proustite upon the decomposed surface of a quartzose vein-stone rich in galena. If some of the loose material be shaken from these specimens and examined under the microscope, it is found to contain numerous minute crystals of rittingerite, proustite in slender prisms with scalenohedral terminations, quartz doubly terminated prisms, and mica. These microscopic plates of rittingerite are honey-yellow and fairly transparent, and have fine linear faces upon their edges. Most of the crystallographic and optical determinations detailed below were made upon this material.

The rittingerite of the second type occurs in somewhat stouter rhombic tables dispersed singly, together with proustite, upon the pseudomorphous sulphide of iron known as "Silberkies;" these have a quartzose vein-stone containing decomposing marcasite and are sometimes accompanied by pearlspar.

On one specimen which consists of nickeline and galena the rittingerite is dispersed, together with proustite, upon the nickeline.

The specimens of the first type are, as is stated by Zippe, from the Hüttenberg of the Eliaszeche.

On all these specimens the rittingerite appears to be contemporaneous with the proustite, and when these minerals occur upon silberkies they have very probably resulted from decomposition of argentopyrite or other silver mineral of which silberkies is an alteration.

(b). *Crystalline form*.—The rittingerite from Joachimsthal always occurs in small rhombic plates, with a plane angle of about 55° , having their edges bevelled by linear pyramid faces.

The larger crystals, and these include most of those which lie upon silberkies, are not suitable for accurate measurement, since they are composite crystals; the large face is curved and uneven, made up of segments belonging to different individuals, and the pyramid faces are composed of very minute striated planes.

Schabus, whose figure is here reproduced with an altered lettering, refers the mineral to the monosymmetric system, the plane of symmetry being parallel to the shorter diagonal and gives the following measurements:—

$$cP = 49^\circ 10'$$

$$c'p = 47^\circ 36'$$

$$cq = 98^\circ 30'$$

$$cr = 30^\circ 0'$$

$$Pp = 83^\circ 40'$$

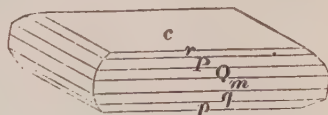


FIG. 5.

In modern notation the axial ratios which he calculates from these measurements are—

$$a : b : c = 0.506398 : 1 : 0.508776$$

$$\beta = 88^\circ 26'$$

Calling the longer diagonal a , and the shorter diagonal unity, in order to bring the crystals into harmony with those described below, we have—

$$a : b : c = 1.975 : 1 : 1.005$$

The symbols of the faces are—

$$P = 111 \quad m = 110$$

$$r = 112 \quad q = 66\bar{1}$$

$$Q = 661 \quad p = 11\bar{1}$$

Schabus further calculates the angles

$$mm = 53^\circ 42' \quad pp = 140^\circ 1'$$

$$PP = 141^\circ 0' \quad Pp = 83^\circ 12'$$

$$Pp = 83^\circ 42'$$

Schrauf proceeded in the following way: (1) the *plane* angle of the rhomb was determined by measurements on one crystal to be $55^{\circ}40'$; the axial angle β was deduced from a second striated crystal which shows on the face *c* a line of junction (twin-union?) parallel to the longer diagonal and a salient angle of $1^{\circ}20'$; on the assumption that this is due to twinning about the orthopinakoid,¹ the angle $100:001$ is taken to be $89^{\circ}20'$, and the plane of symmetry is taken parallel to the shorter diagonal (3) the angle $001:\bar{1}11$ was measured on a third crystal as $48^{\circ}52'$.

From these data the axial ratios are calculated as

$$a:b:c = 0.52812:1:0.52934$$

$$\beta = 89^{\circ}20'$$

Making the shorter diagonal *b* ($=1$) in order to bring the crystals in harmony with those described below, we have

$$a:b:c = 1.8935:1:1.0024$$

The indices of the faces which yield reflections were found to be (112) (334) (332) (16.16.3) (110) (0.16.3).

The very complete account which Schrauf gives of his measurements enables us to select with some confidence those readings which are most reliable, and to attach more weight to them than to the remainder.

It is important to do this, because his results do not accord very closely with those of Schabus nor with my own, and the discrepancies are doubt to be ascribed to the imperfect nature of the crystals.

In the principal zone [*c m p*] it results from the combined observations of Schabus, Schrauf and myself, that there is a set of fairly well defined planes to which we may provisionally give the following letters and positions, corresponding to those used for xanthoconite:—

	Schabus.	Schrauf.	Inclination to <i>c</i> .
<i>m</i>	<i>M</i>	<i>m</i>	about 90°
<i>q</i>	<i>q</i>	<i>q</i>	„ 81°
<i>p</i>		<i>r</i>	„ 60°
<i>P</i>	<i>p'</i>	π	„ 49°
<i>p</i>	<i>p</i>	<i>p</i>	„ 48°
<i>t</i>			„ 36°
<i>r</i>	<i>r</i>	<i>o</i>	„ 30°
<i>f</i>		<i>f</i>	„ 18°

¹ This assumption is incorrect, since, as will be shown, the orthopinakoid is parallel not to the longer but to the shorter diagonal.

The only angles observed by Schrauf for which the readings are given minutes are the following:—

Crystal 5.	$Pq = 31^{\circ}45'$
Crystal 6.	$cp = 47^{\circ}15'$
	$cP = 48^{\circ}25'$
	$cq_1 = 78^{\circ}25'$
	$cq_2 = 79^{\circ}25'$
	$cq = 79^{\circ}$
	$cm = 87^{\circ}45'$
	$cP = 129^{\circ}35'$
Crystal 4.	$*cP = 48^{\circ}52'$
	$cq_1 = 98^{\circ}50'$
	$*cq_2 = 99^{\circ}54'$
	$cP = 130^{\circ}50'$
	$cr = 149^{\circ}56'$
	$cP = 48^{\circ}28'$
	$cq = 79^{\circ}50'$
	$*cq = 98^{\circ}48'$
	$cr = 150^{\circ}35'$
	$pp = 83^{\circ}15'$

The value $99^{\circ}48'$ given for cq on p. 231, must be a misprint.)

The best readings are distinguished by an asterisk.

The interpretation of these angles will be given subsequently; see the table on p. 212.

My own measurements relate to seven crystals: numbers 1-5 are microscopic crystals belonging to the older variety; the last two were taken from silberkies, and belong to the second type.

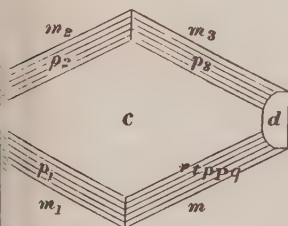


FIG. 6.

With each set of measurements are mentioned all the faces indicated by definite reflections, whether good or bad. The letters refer to fig. 6, which gives a general survey of the rittingerite crystals, and all the fragments measured are supposed to be orientated as in fig. 6. p' is parallel to p , p_1' to p_1 &c., as before.

Here, as in the case of xanthoconite, no account is taken of a vast number of indistinct and banded images obtained in the zone cm .

Crystal 1. Determinable faces, $c P q d p_3$

$$\begin{array}{lll} cp_3 = 47^\circ 39' & p_3 q = 108^\circ 7' & cP = 49^\circ 9' \\ cq = 79^\circ 43' & dq = 60^\circ 57' & \\ *cd = 68^\circ 14' & p_3 d = 56^\circ 17' & \end{array}$$

Crystal 2. Determinable faces, $c r p r_3 q_3 c' r_1'$

$$\begin{array}{ll} cp = 47^\circ 14' & cr_3 = 30^\circ 35' \\ cq_3 = 82^\circ 57' & c'r_1' = 30^\circ 50' \end{array}$$

Crystal 3. Determinable faces, $c m m_3 P_3 c' p' t' q_3' P_2' P_2'$

$$\begin{array}{ll} cp = 47^\circ 27' & c'm = 87^\circ 38' \\ c'P_2' = 49^\circ 2' & c'P_3' = 48^\circ 38' \end{array}$$

Crystal 4. Determinable faces, $c r p m m_2 p_1 r_1 q_2 p_3 c' r_1' p_1' P_3' q$ (an orthodome).

$$c'r_1' = 28^\circ 18' \quad cm = 94^\circ 45' \quad ck = 28^\circ 37'$$

Crystal 5. Determinable faces, $c P q d c' r_2'$

$$c'd = 109^\circ 23' \text{ or } 109^\circ 59' \quad c'r_2' = 30^\circ 9' \quad dP = 56^\circ 3'$$

Crystal 6. Determinable faces, $c q P_3 q_3 c' r_1' q_1' r_2' q_2'$

$$cq = 80^\circ 1' \quad cP_3 = 49^\circ 3' \quad qP_3 = 107^\circ 54' \quad qq_3 = 120^\circ 54' \text{ or } 121^\circ 0'$$

Crystal 7. Determinable faces, $c r P q d P_3 q_3 m_3 P_1' d' r_2' P_2'$

$$\begin{array}{lll} c'd' = 68^\circ 54' & *d'q_3 = 68^\circ 9' & cP_1' = 129^\circ 38' \text{ or } 130^\circ 17' \\ c'r_2' = 31^\circ 32' & d'P_2' = 55^\circ 45' & c'P_2' = 48^\circ 21' \text{ or } 49^\circ 52' \\ cq_3 = 79^\circ 22' & d'r_2' = 57^\circ 49' & \end{array}$$

The best angles are afforded by crystal 1. The faces $q d p_3$ are very perfect and even c yields a single and well defined image. From the three angles cp_3 , $p_3 d$, dc , that between the zones cp_3 and cd is calculated to be $68^\circ 14'$ from the three angles cq , qd , cd , that between the zones cq and cd is calculated to be $62^\circ 41'$. The sum of these is $126^\circ 17'$ and should be plane angle of the face c ; now from the three measurements cp_3 , cq , the same angle is calculated as $126^\circ 22'$. The measurements on this crystal can therefore be relied on as concordant and accurate.

There are three ways in which they may be interpreted, and similar considerations may be applied to each of the remaining six crystals.

(1). The crystal is orthorhombic, and the want of symmetry is merely due to different pyramids being developed upon the different edges.

(2). The crystal is monosymmetric, it being still doubtful whether the plane of symmetry is parallel to the shorter or the longer diagonal of the rhomb.

(3). The crystal is anorthic, since the angle between the zones cp_3 , cd is not absolutely identical with that between cq and cd , as it should be in the monosymmetric system.

In the first place the angles themselves are very nearly in accordance with the requirements of the orthorhombic system.

Thus in the accompanying stereographic projection on a plane which contains the shorter diagonal of the rhomb and the normal to c , the angle $c d q$

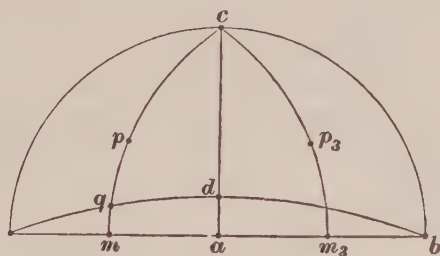


FIG. 7.

calculated from cd , cq and dq is $90^{\circ}6'34''$,

and therefore $bc = 89^{\circ}52'52''$.

Hence taking a as 100

b 010

c 001

p 111

and calculating from $cp = 47^{\circ}39'$

$bm = 63^{\circ}9'$

the crystal may be referred to three rectangular axes

$a : b : c = 0.50642 : 1 : 0.49563$

making a the longer and b the shorter diagonal

$a : b : c = 1.97465 : 1 : 0.97869$,

we get $q = 551$ $cq = 79^{\circ}40'$ (calculated) $79^{\circ}43'$ (observed)

$d = 501$ $cd = 68^{\circ}2'$ „ $68^{\circ}14'$ „

But in this case P either belongs to the form $\{111\}$, and cP should be $47^{\circ}39'$ instead of $49^{\circ}9'$ as observed, or else P has indices approximately to $(21.21.20)$.

It is true that in this crystal the angle cP is precisely the one which is most doubtful, but on the other hand the best angular measurement on crystal 2 gives $49^{\circ}2'$, and one of Schabus' angles is $49^{\circ}10'$.

Further a microscopic examination of this crystal shows that c is nearly perpendicular to a bisectrix, the plane of the optic axes being

parallel to the shorter diagonal of the rhomb. Extinction is parallel to the diagonals, but the bisectrix emerges with a slight inclination (one or two degrees at most) to the normal of c , the divergence being in the longer diagonal of the rhomb.

These considerations negative the orthorhombic and anorthic system and justify us in ignoring the slight difference of $0^{\circ}55'$ between the angles $p c d$ and $q c d$, especially when the individual variations in the remaining crystals are borne in mind; hence we may conclude that the crystal belongs to the monosymmetric system, the plane of symmetry being parallel to the longer diagonal, and not to the shorter diagonal, as supposed by Schabus and Schrauf.

Then, calculating from the data

$$\begin{aligned} c p &= 47^{\circ}39' \\ c q &= 79^{\circ}43' \\ a c p &= 63^{\circ}9' = a c q \end{aligned}$$

and assuming $p = (111)$ and $q = (551)$,

we obtain for this crystal (No. 1) $100 : 001 = 90^{\circ}8'20''$.

Hence within the limits attainable by the measurements the axes may be regarded as rectangular, and the elements and axes deduced from the particular crystal are $a : b : c = 1.97555 : 1 : 0.97879$, $\beta = 90^{\circ}$; then the indices of the faces given in the table on p. 202 are as follows:—

$c = 001$	$q = 551$
$m = 110$	$\rho = 382$
$p = 111$	$t = 223$
$P = 21.21.20$	$r = 112$
$d = 501$	$f = 115$

We have hitherto confined our attention to crystal 1, because the cross-measurements which it affords are extremely good and are concordant, and because they prove that rittingerite may be referred, at least for the present, as a first approximation, to three rectangular axes.

The next step is to combine the measurements from all the six crystals described above, as well as those of Schrauf and Schabus, and as basis for calculation are taken the angle $q d$ as measured on crystal 1, and angle $c q$ as deduced from crystals 1, 2, 6, 7,

$$a : b : c = 1.928 : 1 : 0.995, \beta = 90^\circ.$$

		Observed.	Limits.		No.	Calculated.
<i>cκ</i>	001 : 105	28 37	°	'	1	27 32
<i>cd</i>	001 : 501	69 26	68	14—70 37	4	69 0½
<i>cr</i>	601 : 112	30 16	28	18—31 32	5	29 31
<i>cp</i>	001 : 111	47 27	47	14—47 39	3	48 33
<i>cP</i>	001 : 21.21.20	49 16	48	21—50 22	8	49 56
<i>cq</i>	001 : 551	79 59	79	22—80 13	4	—
<i>c</i>	001 : 771	82 57			1	82 48½
<i>cm</i>	001 : 110	86 26	85	15—87 38	2	90 0
<i>pd</i>	111 : 501	56 17			1	55 59½
<i>pq</i>	111 : 551	108 7			1	107 45
<i>dq</i>	501 : 551	60 57			1	—
<i>dq</i>	501 : 551	68 9			1	68 50½
<i>dP</i>	501 : 21.21.20	55 52	55	45—56 3	2	55 59
<i>qP</i>	551 : 21.21.20	107 54			1	108 57
<i>qq</i>	551 : 551	120 18	120	54—121 42	2	124 38

To compare with the above, we have from Schabus

		Observed.
<i>cP</i>	001 : 21.21.20	49 10
<i>cp</i>	001 : 111	47 36
<i>cq</i>	001 : 551	98 30
<i>cr</i>	001 : 112	30 0
<i>Pp</i>	21.21.20 : 111	83 40

From the reliable measurements of Schrauf the following:—

		Observed.	Limits.		No.
<i>cr</i>	001 : 112	150 15	149 56—150 35		2
<i>cp</i>	001 : 111	47 15			1
<i>cP</i>	001 : 21.21.20	49 4	48 25—50 25		5
<i>cq</i>	001 : 551	79 53	79 0—81 10		7
<i>cm</i>	001 : 110	87 45			1
<i>pp</i>	111 : 111	83 15			1
<i>pq</i>	111 : 551	31 45			1

The correct interpretation of these measurements is to be found in the table of calculated angles on p. 212.

I have here ventured to take the measurements of Schrauf, and to give them a different interpretation from his. The table is simply constructed from the observations on the three crystals quoted on p. 203.

A sufficient justification is to be found in the very complete and intelligible record of measurements published by Schrauf. Here, as in the

case of all imperfect crystals, it is of more importance to have the actual readings than the means deduced from them, and for this reason a similar course has been pursued in the present paper in the description of both xanthoconite and rittingerite, in the hope that they may be corrected and perfected by subsequent observers.

An attempt has here been made to determine the form of the rittingerite from Joachimsthal, independently of any reference to xanthoconite. The nature of the material renders it impossible to do this with accuracy; for instance, the discrepancy between the observed and calculated value of $c\rho$ indicates that the determination is only approximate. It is, however, possible to assert positively that the crystals are rhombs, having a plane angle of about 54° , and belonging to the monosymmetric system referable to three nearly rectangular axes having nearly the ratios 2:1:1 and that the dome face d upon the acute angle of the rhomb is inclined at an angle of about $69\frac{1}{2}^\circ$ to the basal plane.

It is impossible from the measurements *alone* to say with certainty whether the plane of symmetry is parallel to the shorter or longer diagonal of the rhomb; but the evidence is in favour of the latter.

The crystals are almost always composite, consisting of several individuals twinned upon c ; from this cause the face c is very rarely smooth.

Cleavage is distinct, parallel to c .

(c.) *Hardness*.—The hardness is, as stated by Zippe, between 2 and 3.

(d.) *Colour*.—The superficial colour of the crystals belonging to the older occurrence is a dull orange yellow inclined to red; that of the more recent occurrence is a more lustrous orange red, even somewhat resembling proustite on a fractured surface.

By transmitted light thin plates or fragments are always of a clear lemon yellow.

(e.) *Streak*.—The streak is always a vivid orange yellow.

(f.) *Lustre*.—The lustre is adamantine; sometimes inclined to pearly on the face c .

(g.) *Optical Characters*.—As regards magnitude and sign of double refraction, position of the optic axes, dispersion and twinning, thin crystals of rittingerite are identical with xanthoconite.

The axial plane is parallel to the shorter diagonal of the rhombs; the negative bisectrix emerges nearly normal to c , but slightly inclined in the plane of the longer diagonal; birefringence rather strong; $2H = 12^\circ$ or about; $\rho < v$.

All the crystals are composed of overlapping plates twinned on c , which

rise to the same interference figure as that described on p. 196; in all that is said there is applicable to rittingerite.

(h.) *Chemical Characters.* [G. T. PRIOR.]—A complete analysis was impossible owing to lack of material; only about 4 milligrams were available.

The result of the specific gravity determination was as follows:—

(a.) Weight of rittingerite in air = 0.0046 gram.

(β.) Weight of rittingerite with water in the pycnometer when filled to the index mark:—

3.0115	grams at 14°·6	i.e.	3.0109	grams at 16°
3.0114	„	14°·8	3.0109	„ „
3.0109	„	15°·8	3.0108	„ „
3.0110	„	15°·5	3.0110	„ „
3.0110	„	15°·8	3.0109	„ „
3.0114	„	15°·2	3.0110	„ „
3.0109	„	15°·8	3.0108	„ „
3.0108	„	16°	3.0108	„ „

Mean = 3.01089 grams at 16°

(γ.) Weight of water alone in the pycnometer when filled up to the index mark—

3.0072	grams at 16°
3.0072	„ „
3.0071	„ „
3.0072	„ „

Mean 3.00717

Hence specific gravity = 5.2.

This result is the mean value to be deduced from the weighings; but a difference of $\frac{1}{10}$ milligram in any of the weighings corresponds to a difference of about .5 in the specific gravity, all that can be said in dealing with so small a weight of material is that the specific gravity lies between 5 and 6.

In the analysis, all that could be attempted was the determination of silver. For the reasons stated on p. 129, some reliance can be placed on this determination, even with such a small weight of material. The mineral was decomposed in a current of chlorine as in the case of xanthoconite; similar changes of colour were noted during the decomposition, and traces of sulphur were seen to separate on the surface of the white hydrochloric acid in the receiver.

The weight of rittingerite taken was 0.00380 gram, and the weight of silver chloride obtained was 0.00319 gram, which corresponds to 63.2

per cent. of silver; the weight of silver obtained on reduction was 0.00243 gram, which gives 64.00 per cent.

Within the limits attainable this is practically identical with the results for Xanthoconite.

As regards the other constituents absorbed in the dilute hydrochloric acid in the receiver, the presence of sulphur was clearly demonstrated by precipitation with barium chloride. This precipitate and the filtrate were carefully tested for selenium by means of sulphur dioxide, but with negative results. The arsenic was precipitated by H_2S ; the precipitate was somewhat dark-coloured, but no antimony could be detected by the barium tartrate microchemical test in the slight residue obtained on treating with hot strong hydrochloric acid and evaporating down. On the other hand the presence of arsenic was confirmed by oxidising with nitric acid and precipitating with magnesia mixture.

Portions of the matrix from two specimens of rittingerite were tested for selenium, but with negative results.

In opposition to the above we have the investigation of Schrauf, who found that rittingerite contains silver, arsenic, and *selenium*, with a silver percentage of 57.7.

We must contend, however, that the method which we have employed for the determination of the silver is more reliable than the method (reduction on charcoal) made use of by Schrauf, and point out that the only proof which he gives of the presence of selenium is the smell which he noticed on heating the mineral.

On the other hand, in confirmation of the absence of selenium, we have the micro-chemical observations of Streng.

V. THE IDENTITY OF XANTHOCONITE AND RITTINGERITE.

In the preceding sections it has been necessary, in order to make the proof complete, to keep the observations on the two minerals perfectly distinct. In the absence of complete analyses each has been treated as a separate mineral, and the calculations have been made independently.

Brought into the same position, and referred to the same parametrical plane, the different crystals which have been measured have received the following axial ratios:—

Xanthoconite (Freiberg)	1.921	: 1 :	1.034	$\beta = 90^\circ$	Miers
„ (Markirch)	1.936	: 1 :	1.003	$\beta = 90^\circ$	„
„ (Chañarcillo)	1.906	: 1 :	0.972	$\beta = 90^\circ$	Streng
Rittingerite	1.8935	: 1 :	1.002	$\beta = 89^\circ 20'$	Schrauf
„	1.975	: 1 :	1.005	$\beta = 88^\circ 26'$	Schabus

Rittingerite (Crystal 1)	1.975	: 1 : 0.979	$\beta = 90^{\circ}0'$	Miers
„	1.928	: 1 : 0.995	$\beta = 90^{\circ}0'$	„

The angle β of Schrauf and Schabus is that of the axes $b c$.

These numbers in themselves suggest forcibly that they all relate to one and the same mineral.

The preceding pages have completed the evidence by establishing those characters which were left doubtful by previous observers, namely, the form of xanthoconite and the composition of rittingerite, and have proved conclusively that the two substances are identical in composition and physical characters, as well as crystalline form.

The independent calculations have now therefore become superfluous; the axial ratios given above are only first approximations, and we may now fix the crystalline form of the mineral xanthoconite by combining the measurements of both varieties, recollecting that the crystals are almost invariably twinned.

The chief difficulties to be decided are (1) whether the angle β differs appreciably from 90° ; (2) which of the forms belong to positive and which to negative hemi-pyramids; (3) which of the angles obtained for $001 : 111$ or p is correct.

The following are the very best individual angles measured:—

Xanthoconite	$cm = 90^{\circ}8'$
	$am = 62^{\circ}28'$
	$mm = 55^{\circ}5'$ (mean of $55^{\circ}3'$ and $55^{\circ}7'$)
	$dq = 61^{\circ}2'$
	$cp = 48^{\circ}23'$ (mean of $48^{\circ}10'$ and $48^{\circ}36'$)
	$pp = 83^{\circ}7'$
	$cy = 56^{\circ}9'$
Rittingerite	$cd = 68^{\circ}14'$
	$d'q = 68^{\circ}9'$

In the first place, it may be regarded as certain that $62^{\circ}28'$ is the true angle for am , since it agrees exactly with the angle measured for $m m$.

Next, taking $am = 62^{\circ}28'$ and $d q = 61^{\circ}2'$, and assuming that the zone q is perpendicular to the zone $c d$ in accordance with the requirements of the monosymmetric system, and as proved to be the case on crystal 1, we calculate $c d$ as approximately $70^{\circ}21'$, which does not agree with the measured angle $68^{\circ}14'$; it does, however, agree with the angle determined in the Markkirch xanthoconite, and this suggests that the one angle $c d = 68^{\circ}14'$ may belong to the negative, and the other $c D = 70^{\circ}21'$ to the positive orthodome (101).

From these values $001 : 501 = 68^{\circ}14'$

$001 : \bar{5}01 = 70^{\circ}21'$

we calculate

$ac = 100 : 001 = 88^{\circ}47\frac{1}{2}'$

$cm = 001 : 110 = 89^{\circ}26'$

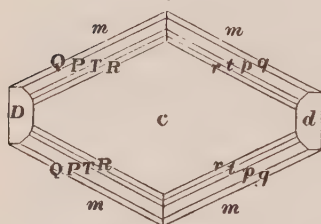


FIG. 8.

The angle ac is nearly identical with ca measured on the Markirch mineral and cm is comparable with the angle $89^{\circ}52'$ obtained from Freiberg xanthoconite.

Without, therefore, pretending to any great degree of accuracy, we may refer the mineral to the following elements:-

$$a : b : c = 1.9187 : 1 : 1.0152$$

$$\beta = 88^{\circ}47'$$

with the angles

ac	$100 : 001$	$88^{\circ}47'$	cY	$001 : \bar{4}43$	$57^{\circ}19'$
	$001 : 101$	$27^{\circ}37'$	cq	$001 : 551$	$79^{\circ}32'$
	$001 : \bar{1}01$	$28^{\circ}9'$	cQ	$001 : \bar{5}51$	$80^{\circ}38'$
cd	$001 : 501$	$68^{\circ}14'$	pp	$111 : \bar{1}\bar{1}\bar{1}$	$83^{\circ}18'$
cD	$001 : \bar{5}01$	$70^{\circ}21'$	PP	$\bar{1}\bar{1}\bar{1} : \bar{1}\bar{1}\bar{1}$	$84^{\circ}18'$
cn	$001 : 053$	$59^{\circ}24'$	qq	$551 : \bar{5}\bar{5}\bar{1}$	$121^{\circ}21'$
cm	$001 : 110$	$89^{\circ}26'$	QQ	$\bar{5}51 : \bar{5}\bar{5}\bar{1}$	$122^{\circ}6'$
am	$100 : 110$	$62^{\circ}28'$	pd	$111 : 501$	$55^{\circ}27'$
mm	$110 : \bar{1}\bar{1}0$	$55^{\circ}4'$	PD	$\bar{1}\bar{1}\bar{1} : \bar{5}01$	$56^{\circ}41'$
cr	$001 : 112$	$29^{\circ}38'$	dq	$501 : 551$	$60^{\circ}40'$
cR	$001 : \bar{1}\bar{1}2$	$30^{\circ}12'$	DQ	$\bar{5}01 : \bar{5}\bar{5}\bar{1}$	$61^{\circ}3'$
ct	$001 : 223$	$37^{\circ}8'$	dD	$501 : 50\bar{1}$	$41^{\circ}24'$
cT	$001 : \bar{2}\bar{2}3$	$37^{\circ}48'$	pD	$111 : 50\bar{1}$	$84^{\circ}8'$
	$001 : 334$	$40^{\circ}24'$	Pd	$\bar{1}\bar{1}\bar{1} : \bar{5}0\bar{1}$	$85^{\circ}16'$
	$001 : \bar{3}\bar{3}4$	$41^{\circ}7'$	Dq	$50\bar{1} : 551$	$68^{\circ}27'$
cp	$001 : 111$	$48^{\circ}32'$	pq	$111 : 551$	$31^{\circ}0'$
cP	$001 : \bar{1}\bar{1}\bar{1}$	$49^{\circ}10'$	PQ	$\bar{1}\bar{1}\bar{1} : \bar{5}\bar{5}\bar{1}$	$31^{\circ}27'$
cy	$001 : 443$	$56^{\circ}22'$			

If these angles be compared with the measurements given in the table above, it will be found that they agree more closely with the best readings than do the angles previously calculated on the assumption that $\beta = 90^{\circ}$.

As regards the angle $c\ p$ or $c\ P$, three values have been found, namely:—

$$\begin{aligned} c\pi &= 47^\circ 27' \text{ on rittergerite} \\ c\rho &= 48^\circ 18' \text{ on xanthoconite} \\ cP &= 49^\circ 22' \text{ on both.} \end{aligned}$$

According to the above interpretation, the two latter are the positive and negative hemi-pyramids. It is impossible to ignore the face π , because it also occurs in the measurements of Schrauf and Schabus. It is, of course, conceivable that the mineral may be in reality anorthic, but in the present state of our knowledge it is better to regard this plane as a face vicinal to p or P . The crystals described above indicate that it occurs in the positive octants, and is therefore vicinal to P .

We have then, finally, for the characters of xanthoconite

System monosymmetric

$$a : b : c = 1.9187 : 1.10152 \quad \beta = 88^\circ 47'$$

common forms

p	111	P	$\bar{1}11$
q	551	Q	$\bar{5}51$
d	501	D	$\bar{5}01$
m	110	c	001

usual habit, fig. 1; from Joachimsthal (rittingerite) fig. 6; from Marienberg, fig. 2.

Twin-plane c , common. Cleavage distinct, c ; fracture, subconchoidal; brittle; hardness between 2 and 3; sp. g. = 5.54; lustre, adamantine to nearly; superficial colour, brown, orange or red; colour by transmitted light, lemon yellow; streak, orange yellow; optic axial plane perpendicular to the plane of symmetry; birefringence strong, negative; $2E$ about 225° ; $\rho < v$; acute bisectrix nearly normal to c .

Composition; Ag_3AsS_3 or $3\text{Ag}_2\text{S} \cdot \text{As}_2\text{S}_3$

$$\text{Ag} = 65.4, \text{As} = 15.2, \text{S} = 19.4.$$

VI. THE FAMILY OF THE RED SILVERS.

In the group of the red silvers are to be included the sulph-arsenites and sulph-antimonites of silver which have received the names of proustite, pyrrargyrite, xanthoconite, rittergerite, sanguinite and fireblende.

Rittergerite and xanthoconite are now to be united under the latter name, rittergerite being only a synonym for the Joachimsthal occurrence.

Fireblende, according to the analysis of Hampe, has the composition of pyrrargyrite (*Zeits. f. Krystallographie*, vi. (1882) 572); we should there-

fore expect it to be isomorphous with xanthoconite, considering the well established isomorphism of pyrrargyrite and proustite.

According to the measurements of Luedecke, fireblende belongs to the monosymmetric system

$$a : b : c = 0.3547 : 1 : 0.1782$$

$$\beta = 90^{\circ}0'$$

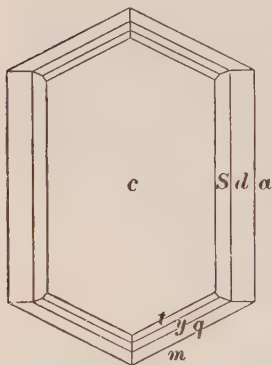


FIG. 9.

Now the mineral crystallises in thin plates with a habit which instantly reminds one of that of xanthoconite. It has a prism angle ($53^{\circ}21'$) near that of xanthoconite ($55^{\circ}5'$) and it shows the same tendency to parallel or nearly parallel grouping. The crystals consist of bundles or sheaves of thin plates, and are almost invariably overlapping twins, as remarked by Luedecke.

The accompanying figure shows the form of fireblende as determined by Luedecke, but the orientation and lettering of the crystal are

altered so as to bring them into harmony with those adopted for xanthoconite.

According to Luedecke and previous observers (Miller and Roemer) the plane of the plate is the plane of symmetry; but the crystals are nearly orthorhombic in form, and Luedecke's measurements show that they may, like xanthoconite, be referred to three rectangular axes.

With the new position and parametral plane, the axial system is

$$a : c : b = 1.9465 : 1 : 1.0973$$

$$\beta = 90^{\circ}0'$$

$$c = 010 \text{ (} b \text{)}$$

$$y = 434 \text{ (} \rho \text{)}$$

$$m = 101 \text{ (} d \text{)}$$

$$q = 515 \text{ (} \pi \text{)}$$

$$a = 001$$

$$S = 520 \text{ (} S \text{)}$$

$$t = 232 \text{ (} \sigma \text{)}$$

$$d = 510 \text{ (} m \text{)}$$

The letters in brackets are those used by Luedecke. The letters used here are chosen to indicate the probable identification of the faces observed by Miller and Luedecke, the calculated angles being

$$mm = 53^{\circ}21'$$

$$ct = 34^{\circ}54'$$

$$cy = 57^{\circ}30'$$

$$cq = 72^{\circ}20'$$

$$cS = 54^{\circ}39'$$

$$cd = 70^{\circ}28'$$

The measurements of Luedecke are by no means concordant, neither do they agree with those of Miller, so that the form of fireblende cannot be regarded as determined with certainty.

The face *c* is regarded as the plane of symmetry on account of the optical characters. Luedecke found that the direction of extinction is not straight, but makes an angle of 8° — 11° with the edge *cd*. That the direction of extinction cannot be straight is proved by the fact that the twin crystals do not become dark in any position between crossed nicols.

This indicates that the symmetry is certainly different from that of xanthoconite; but the geometrical similarity of the two substances is so great that they must necessarily be considered as isomorphous.

We have, then, in these two minerals, a very interesting example of isomorphism in the same system with different orientation. They crystallise in rhombic-shaped plates, having an angle of about 54° , and belonging to the monosymmetric system: but whereas in xanthoconite the plane of symmetry is perpendicular to the plate and parallel to its longer diagonal, in fireblende it is parallel to the plane of the plate.

The present paper brings to a close the researches which I have made, with the help of Mr. Prior, during a course of several years, into the nature of the red silver ores.

We may now gather up the information which we possess regarding this interesting group of minerals, and classify the red silvers as follows:—

	Rhombohedral.	Monosymmetric.
Sb_3S_3	Pyrargyrite	Fireblende
	$a : c = 1 : 0.7892$	$a : c : b = 1.9465 : 1 : 1.0973$
	$G = 5.85$	$\beta = 90^{\circ}0'$
		$G = 4.3$ (?)
As_3S_3	Proustite	Xanthoconite
	$a : c = 1 : 0.8038$	$a : b : c = 1.9187 : 1 : 1.0152$
	$G = 5.57$	$\beta = 88^{\circ}47'$
		$G = 5.54$

Pharsenite of silver—sanguinite—probably rhombohedral.

It is evident that a more complete and accurate determination of fireblende is needed. The specific gravity is probably greater than 4.3, the number given by Miller. The material in the British Museum is not, however, suitable for accurate measurements, and I am obliged to content myself with the observations of Luedecke, merely adding to his description the fact that the mineral has strong positive birefringence.

It results from the preceding comparison that the analogy between the

red silvers and the calcite-aragonite groups is not so close as is often stated. The second modifications of pyrargyrite and proustite are not orthorhombic as was supposed to be indicated by bournonite, but are monosymmetric and present no similarity to aragonite. There is no reason to regard the red silvers as in any sense isodimorphous with the carbonates, and we are not justified in supposing that the similarity of angle in the rhombohedral modifications is due to a similarity of composition,

NOTE.—The general results of the present paper were stated in *Nature*, Vol. 47, p. 70.

*a discovery of " Oriental Ruby " and " Margarite " in the Province of
Westland, New Zealand.*

By Prof. G. H. F. ULRICH, F.G.S., of Dunedin University.

Communicated by Prof. J. W. JUDD, F.R.S.

[Read January 17th, 1893.]

In the early part of this year Mr. W. Goodlet, laboratory assistant to Prof. Black, of the Dunedin University, submitted to me for examination a mineral specimen which he had brought from a journey of inspection of the gold fields of the West Coast, Middle Island. It had, so he told me, been broken from a boulder, about 40 lbs. in weight, which was found in the gold drift of a claim at Back Creek near Rimu, Westland, and placed aside by the claim owners as something uncommon, because of its weight and colour. The specimen was seen to be composed of a crystallised red mineral and a massive one of green colour, and the former I easily recognised by its hardness, crystalline form and pleochroism as ruby. Acting upon this information Mr. Goodlet was fortunate enough to secure from the claim owners several other small fragments of the boulder, and from a further examination of these I found the following:—

The ruby crystals appear throughout in slightly barrel-shaped hexagonal forms with the basal planes, and on a few could be discerned minute angular replacements of alternate basal corners, *i.e.* planes of a rhombic prism as noticed on rubies of other localities. The prisms are closely packed horizontally, and range in length from 2 up to 6 mm., and in thickness from less than 1 mm. to rarely 2 mm. and slightly over. The colour of some is a fine rose-red, approaching carmine, but most are of a deep rose-red and rather dull, the larger ones generally showing dark, dull inclusions with clearer portions of brighter red intermediate. Perfectly clear and finely coloured grains can, however, easily be picked out for examination showing the characteristic strong pleochroism of the ruby. Whilst some of the fragments the crystals are scarce, or in but moderate

abundance mixed with or embedded in the green mineral, in others they are so densely aggregated and intergrown as to produce a veritable rock, with the green mineral appearing only in scattered small patches. There are, however, also pieces which consist only of the green mineral. At several places in one fragment there are seen in the latter between the rubies small bunches of minute acicular radiating crystals of a dark brownish green colour which may be either tourmaline or epidote, though more likely the former, judging from the rather triangular outline in cross section of some of the needles.

Regarding the green mineral, its colour varies between light and dark emerald green, and, though principally quite massive, there are seen in the specimens lighter coloured portions which are fine-scaly and have a pronounced pearly lustre. As in a number of localities in North America and Asia Minor, margarite occurs associated with corundum, and it is probable that, notwithstanding its green colour, the mineral under notice might also belong to this species. At my suggestion, therefore, Mr. P. Marshall, B.A., B.Sc., kindly made a quantitative analysis of a massive piece of a medium shade of green colour, which gave the following results:—

SiO ₂	...	...	...	...	35.83	
Al ₂ O ₃	...	...	...	...	45.96	
Fe ₂ O ₃	...	...	...	...	1.29	
Cr ₂ O ₃	...	...	...	...	0.02	
CaO	...	...	...	...	10.09	
MgO	...	...	...	...	0.93	
K ₂ O	...	...	...	...	0.39	} 1
Na ₂ O	...	...	...	...	4.74	
H ₂ O	...	...	...	...	2.85	
					102.10	

Although summing up rather unsatisfactorily, these results, on comparison with those of a number of analyses of margarite recorded in the mineralogies of Dana and Hintze, may be regarded as sufficiently close to place the New Zealand associate of corundum also under the lime-mica margarites, as surmised. Its green colour is doubtless due to sesquioxide of chromium, and the varying shades depend upon amounts of the latter entering into the composition. Small as the trace shown in the analysis is, it proved quite sufficient to impart a green colour.

¹ Separately determined by Mr. H. Walcott.

The borax bead on some of the powdered mineral being added. The mineral breaks with a splintery fracture ; hardness 3·5 ; specific gravity 2·25. In the closed glass tube it yields, on strong heating, a small amount of water which reacts alkaline ; it is not decomposed by acids. Thin splinters turn white before the blowpipe and fuse with some difficulty at the edges to an enamel of a fine pink colour—a reaction verified by a number of trials, and probably also attributable to the small trace of chromium sesquioxide, whilst also pointing to the correctness of the accepted supposition of the colour of the ruby being due to this oxide. Although the owners of the claim at Back Creek were directly informed of the nature and value of their discovery, and of the probability of the heavy sand obtained during the process of gold washing containing rubies of some value in jewellery, no new find of the precious stone has since been reported. The gold drift of the locality is, according to Sir James Hector, mainly composed of moraine matter, derived from the high crystalline schist ranges inland, and it does not lie outside the bounds of probability that a hardy prospector may some day in these ranges discover the place of derivation of the ruby boulder, where really valuable gems are very likely hidden.

Binnite from Imfeld in the Binnenthal.

By C. O. TRECHMANN, Ph.D., F.G.S.

[Read April 18th, 1893.]

THIS rare mineral, the Dufrenoy'site of von Waltershausen and other crystallising in the cubical system, has been made the subject of careful investigation by several observers, with the result that, up to the present moment, it is doubtful whether the character of its forms is holohedral or hemihedral with inclined faces. Hessenberg¹ found that the mineral crystallised holohedrally, but Groth,² confirming Kenngott's³ view, states that the best crystal in the Strassburg University collection shows a distinctly hemihedral development. Mr. Lewis,⁴ having examined the specimen in the British Museum, found that several forms were developed only in alternate octants, and were consequently hemihedral, yet that others appeared in adjacent octants, and therefore possessed holohedral symmetry, and concluded that further researches were desirable to permit of a final decision of the question.

As a further contribution towards its solution, it is hoped that the following description of two very perfect crystals, brought by the writer from the Binnenthal in the year 1875, may prove of interest, the more so, as in this instance the hemihedral character is typically exemplified, both in the distribution of the forms and in the physical nature of the faces, which upon one of the crystals could be examined in all the eight octants, a somewhat unusual occurrence in the case of an attached crystal.

A comparison of the results given below, with Hessenberg's description, leads to a suspicion that possibly two different cubical minerals are here involved, and that the holohedral and hemihedral cr

¹ *Mineralog. Notizen*, Heft. IX., 1875, p. 6. *Abhandl. d. Senckenberg. Naturforsch. Gesellsch. in Frankf.*, Bd. X.

² *Mineralien Sammlung d. Univ. Strassburg*, 1878, p. 59.

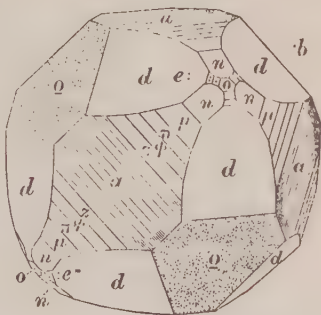
³ *Uebers. Min. Forsch.*, 1856, u. 57. *Die Minerale der Schweiz*, 1866, p. 378.

⁴ *Proceed. Crystallog. Soc.* II., 53, 1877, and *Zeitschr. f. Kryst.* II., 192, 1878.

may not be of the same substance, a suspicion strengthened somewhat by the fact that the results of chemical analysis are conflicting, and that the true chemical composition, generally assumed as conforming to the formula $\text{Cu}_6\text{As}_4\text{S}_9$, is as yet a matter of some doubt. It would certainly be of interest if a chemical investigation could be carried out upon crystals of binnite, showing a holohedral character on the one hand, and of hemihedrally developed crystals on the other. The great rarity of the mineral, and the restriction of its occurrence to a single locality,¹ will in all probability preclude the solution of this question by chemical means. The possibility of the existence of two distinct minerals is negatived again to a large extent by the occurrence of the same crystallographic forms on the specimens hitherto described, and also by the coincidence of the general physical characters, such as colour, lustre and fracture.

The crystals to be described were on different specimens of the white binnite; crystal No. 1, in size about 3.5 mm. in its longest dimension, was attached in a small cavity immediately to the dolomite, and associated with yellow blende, pyrites, massive sulpharsenite (probably arsenite), barytocelestine, quartz and hyalophane. On this crystal the octants, namely, three positive and one negative, could be satisfactorily examined. The other crystal, No. 2, about 2 mm. long and very symmetrically developed, was attached to a group of small pyrites crystals within a small cavity of the dolomite, in such manner that, after removal from the matrix, it could be examined in all its octants, the point of attachment only covering a portion of a hexahedral and a few adjoining faces. The accompanying minerals in this case are pyrites, a rhombic sulpharsenite (probably dufrénoysite, v. Rath), and minute crystals of galenite and white mica.

In both crystals the forms (110) , (100) , $\kappa(1\bar{1}1)$ are about equally developed, the $\kappa(211)$ prominent on the positive octants; $\kappa(111)$ is well developed in crystal No. 2, but excessively minute as a single face in crystal No. 1. The distribution and relative size of the principal subordinate forms is illustrated in the accompanying figure, which has been drawn to represent the natural crys-



tals as closely as possible. Most of the crystal faces are smooth, even and highly polished, with sharp and well defined combination edges, but faint striations are noticeable on the faces of (100) and κ (211) and the subordinate κ (hkk) in the zone (100): κ (111); κ ($\bar{1}\bar{1}1$) is slightly dull in crystal No. 1 and dull and corroded in No. 2, the corrosion producing striæ parallel to the combination edges with (110). If a small spot of light is allowed to reflect from the disintegrated surface of κ ($\bar{1}\bar{1}1$) into the eye, an optical figure ("Licht-figur") is seen which forms a symmetrical six-rayed star, the rays meeting in angles of 60° and being vertical to the above combination edges. In the positive octants of crystal No. 2 surrounding the κ (111) faces there is an assemblage of curved faces of hexakistetrahedrons, which are not all determinable, and appear to be due to subsequent corrosion of the combination edges, and in crystal No. 1 the combination edges of (100) with (110) and κ ($\bar{1}\bar{1}1$) are apparently slightly truncated by a striated corrosion face, as represented in the figure, which coincides in its reflection in the telescope of the goniometer with the face κ ($\bar{1}61$) and appears to be due to an oscillatory recurrence of this form upon the boundaries of (100).

The hemihedral nature of these crystals is therefore well characterized by the striations on the faces in the zone (100): κ (111) and by the corrosion of the κ ($\bar{1}\bar{1}1$) faces, and finally by the almost complete restriction to the positive octants of the (hkk), (hhl) and (hkl) forms, the exceptions being the occurrence of a single isolated narrow and ill defined face of κ ($2\bar{1}1$) and of several very small κ ($h\bar{h}l$) faces in the negative octants of crystal No. 2.

Both crystals were measured in all the principal zones, and all forms hitherto established on the mineral binnite were recognised, with the exception of (821). In addition to these, a number of other forms of which the data are given in the table below, were determined. Of chief interest among these centres is the extraordinary number of reflections obtained from narrow κ (hkk) faces in the zone (100): κ (111), most of which were sufficiently distinct to permit goniometrical measurement, and their calculated indices conform fairly well with axial intersections which form terms of an arithmetical series, progressing by decaparts of the unit intersection.¹

¹ Compare: H. A. Miers, Contributions to the study of Pyrargyrite and Proustite, *Min. Mag.* VIII., 87.

Indices.		Axial Ratio $n_a : a$		Crystal No. 1.		Crystal No. 2.		Observer.	Remarks.
Miller.	Naumann.	Calculated : 100.	No. of Edges.	Measured Mean.	Limits.	No. of Edges.	Measured Mean.		
∞	100	$\infty 0\infty$	1	0°3'		2	0°0 $\frac{1}{4}$ '	Heusser	Finely striated
d	110	90°0'	2	90°1 $\frac{1}{2}$ '	90°0'-90°3'	11	90°0'	Damour	Smooth and brilliant
o	κ (111)	54°44'8"	1	54°35'		9	54°44'	Heusser	Smooth and brilliant
o	κ ($\bar{1}\bar{1}\bar{1}$)	54°44'8"	2	54°46 $\frac{1}{2}$ '	54°43 $\frac{1}{2}$ '-54°50'	12	54°44'2"	"	Corroded and striated
	κ (755)	45°15'22"				1	45°17'15"	"	Linear, very faint re- flection
	κ (855)	41°28'23'				1	41°27'	"	Linear, weak reflection
	κ (17.10.10)	39°45'24"				1	40°23 $\frac{1}{2}$ '	"	Linear, exceedingly faint
	κ (955)	38°9'21"				1	37°40'	"	Linear, distinct reflec- tion
	κ (19.10.10)	36°39'40"				2	36°44 $\frac{1}{2}$ '	"	Linear, faint reflections
	κ (211)	35°15'52"	4	35°16'38"	35°15 $\frac{1}{2}$ '-35°18'	10	35°14'18"	Damour	Smooth or faintly stria- ted, brilliant
	κ (21.10.10)	33°57'28"				1	33°37'	"	Linear, indistinct re- flection
	κ (12.5.5)	30°30'32"	1	30°24 $\frac{1}{2}$ "				"	Linear, fairly good re- flection
	κ (522)	29°29'46"				4	29°34'53"	"	Linear, good reflections

TABLE—Continued.

Indices.		Axial Ratio $a : c$	Calculated : 100.	Crystal No. 1.		Crystal No. 2.		Observer.	Remarks.
Miller.	Naumann.			Measured Mean.	Limits.	Measured Mean.	Limits.		
κ (13.5.5)	$+\frac{13013}{2}$	2.6	28°32'50"			28°40'	28°26'–28°54'		Linear, fairly good re- flections
κ (27.10.10)	$+\frac{47047}{2}$	2.7	27°38'41"			27°35'			Linear, approximate
κ (14.5.5)	$+\frac{14014}{2}$	2.8	26°47'50"			26°43'	26°36'–26°50'		Linear, do.
κ (311)	$+\frac{303}{2}$	3.0	25°14'22"			24°53'53"	24°39'–25°24'		Linear, fairly good re- flections
κ (16.5.5)	$+\frac{16016}{2}$	3.2	23°50'34"			23°43'			Linear, very faint
κ (722)	$+\frac{707}{2}$	3.5	22°0'6"			21°54½'	21°40½'–22°10'		Linear, good and dis- tinct reflections
κ (19.5.5)	$+\frac{19019}{2}$	3.8	20°24'48"			20°25'	20°5'–20°36'		Do. do.
κ (411)	$+\frac{404}{2}$	4.0	19°28'16"			19°21'	19°1'–19°32½'	Hessenberg	Linear, good reflections
κ (922)	$+\frac{909}{2}$	4.2	17°26'47"			17°19½'	17°55'–17°56'		Linear, distinct
κ (47.10.10)	$+\frac{47047}{2}$	4.7	16°44'47"			16°41'	16°36'–16°55'		Do. do.
κ (511)	$+\frac{505}{2}$	5.0	15°47'36"			15°30'			Linear, weak reflections
κ (11.2.2)	$+\frac{11011}{2}$	5.5	14°25'12"			14°30'			Linear, very indistinct

Miller.	Naumann.	Axial Ratio $\mu : a.$	Calculated : 100.	No. of Edges.	Measured Mean.	Limits.	No. of Edges.	Measured Mean.	Limits.	Observer.	Remarks.
π	κ (611)	$606 + \frac{2}{2}$	6.0	3	13°15'50"	13°12'–13°20' $\frac{1}{2}$	10	13°22'3"	12°57'–13°45'	Heusser	Very good reflections
	κ (13.2.2)	$1301\frac{13}{2} + \frac{2}{2}$	6.5	2	12°41'	12°2'–12°7'					Linear, very faint
	κ (711)	$707 + \frac{2}{2}$	7.0	1	11°24'					Lewis	Do. do.
	κ (37.5.5)	$3703\frac{37}{2} + \frac{2}{2}$	7.4	1	10°50 $\frac{1}{2}$ '						Do. do.
	κ (811)	$808 + \frac{2}{2}$	8.0		10°1'30"		1	9°56 $\frac{1}{2}$ '			Do. faint
ϕ	κ (911)	$909 + \frac{2}{2}$	9.0	2	8°50 $\frac{1}{2}$ '	8°36'–9°5'	1	8°23 $\frac{1}{2}$ '			Do. do.
γ	κ (10.1.1)	$10010 + \frac{2}{2}$	10.0		8°2'58"		2	7°52 $\frac{1}{4}$ '	7°36 $\frac{1}{4}$ '–8°8'	Hessenberg	Do. very faint
	κ (12.1.1)	$12012 + \frac{2}{2}$	12.0		6°43'17"		1	6°46'			Do. faint
z	κ (16.1.1)	$16016 + \frac{2}{2}$	16.0	2	5°12 $\frac{1}{2}$ '	5°0'–5°25'	1	5°23'			Do. very faint
	κ (28.1.1)	$28028 + \frac{2}{2}$	28.0		2°53'23"		1	3°4 $\frac{1}{4}$ '			Do. do.
	κ (34.1.1)	$34034 + \frac{2}{2}$	34.0	1	2°22'55"						Do. do.
	κ (76.1.1)	$76076 + \frac{2}{2}$	76.0		1°3'58"		2	1°4 $\frac{1}{4}$ '	0°50 $\frac{1}{4}$ '–1°18'		Do. fairly distinct

TABLE—Continued.

Indices.	Miller.	Naumann.	Axial Ratio $a:b:c$	Calculated : 100.	Crystal No. 1.			Crystal No. 2.			Observer.	Remarks.
					No. of Edges.	Measured Mean.	Limits.	No. of Edges.	Measured Mean.	Limits.		
a	$\kappa(211)$	$-\frac{202}{2}$	2.0	$35^{\circ}15'52''$				1	$34^{\circ}29'$			Linear, indistinct, apparently a corrosion face
	$\kappa(28.\bar{1}.1)$	$-\frac{28028}{2}$	28.0	$2^{\circ}53'29''$	1	$2^{\circ}50\frac{1}{2}'$						Linear, very faint
b	$\kappa(332)$	$+\frac{30}{2}$		100 : hkl	2	$25^{\circ}7'$	$25^{\circ}5' - 25^{\circ}9'$	8	$25^{\circ}3'$	$24^{\circ}50' - 25^{\circ}12'$	Heusser	Small faces, good reflections
γ	$\kappa(886)$	$+\frac{30}{2}$		$23^{\circ}50'34''$				4	$23^{\circ}57'$	$23^{\circ}21' - 24^{\circ}28'$		Not distinct
	$\kappa(994)$	$+\frac{30}{2}$		$17^{\circ}26'47''$				1	$17^{\circ}18\frac{1}{4}'$			Fairly distinct
c	$\kappa(552)$	$+\frac{30}{2}$		$15^{\circ}47'36''$	1	$16^{\circ}3'$		2	$15^{\circ}51'$	$15^{\circ}50' - 15^{\circ}52'$		Well defined reflections
	$\kappa(12.12.1)$	$+\frac{120}{2}$		$3^{\circ}22'20''$	1	$3^{\circ}23'$						Uncertain, not quite zonal
	$\kappa(30.30.1)$	$+\frac{300}{2}$		$1^{\circ}21'$	1	$1^{\circ}19'$						Distinct reflections

TABLE--Continued.

Indices.	Axial Ratio $a : c$.		Calculated : 100.	Crystal No. 1.		Crystal No. 2.			Observer.	Remarks.
	Miller.	Naumann.		Measured Mean.	Limits.	No. of Edges.	Measured Mean.	Limits.		
r	κ (885)	$\frac{50}{2}$		23°50'34"		1	24°15'			Very faint ¹
p	κ (221)	$\frac{20}{2}$		19°28'16"		1	18°46'			Very faint ¹
q	κ (552)	$\frac{50}{2}$		15°47'36"		1	15°24'			Very faint and ill de- fined
	κ (331)	$\frac{30}{2}$		18°15'46"		2	13°44 $\frac{1}{4}$ '	13°29 $\frac{1}{2}$ '-14°0'	Hessenberg	Very faint ¹
s	κ (441)	$\frac{40}{2}$		10°1'30"		1	9°39'			Very faint ¹
	κ (13.13.1)	$\frac{130}{2}$		6°12'30"		1	6°18'			Very faint and ill de- fined
σ	κ (321)	$\frac{30\frac{3}{4}}{2}$		$hkl : khl$ 21°47 $\frac{1}{4}$ '					v. Walters- hausen	Not observed
	κ (23.12.11)	$\frac{330\frac{3}{4}}{2}$		2°52'44"		2	2°53'	2°48'-2°58'		Very faint, but fairly well defined, faces rounded

¹ Forming a group.

A number of these narrow faces, some of which need further confirmation, belong apparently to the class of vicinal planes, and others, such as κ (16 1 1), may be due to subsequent corrosion, and thus belong to the order of prerasion planes, as defined by Hamberg.¹

The preceding table gives the forms observed on these crystals, with the calculated and measured angles, the arithmetical mean and the limits, and the number of edges measured is stated when observed more than once.

A reference to the calculated angles reveals quite a series of analogies between faces of different forms, especially between the inclination of the (100) : (hkh) and the (110) : (hhl) faces, where the general expression obtains; angle (100) : ($h11$) = angle (110) : ($hh2$). Hessenberg (l.c.) already refers to such analogies as the expression of an interesting crystallographic problem. Among such cases of identity, which could no doubt be easily multiplied, may be noticed :

$$(111) : (1\bar{1}1) = (211) : (2\bar{1}\bar{1}) = 70^{\circ}31'44''$$

$$(111) : (100) = (110) : (112) = 54^{\circ}44'8''$$

$$(211) : (121) = (110) : (411) = 33^{\circ}33'26''$$

$$(100) : (511) = (110) : (552) = (211) : (411) = 15^{\circ}47'36''$$

$$(111) : (110) = (100) : (211) = 35^{\circ}15'52''$$

$$(111) : (211) = (100) : (411) = (110) : (221) = 19^{\circ}28'16''$$

$$(111) : (441) = (100) : (311) = (110) : (332) = 25^{\circ}14'22''$$

The forms represented on the figure are :

$$a = (100), d = (110), o = \kappa (111), \bar{o} = \kappa (1\bar{1}1), n = \kappa (211),$$

$$\mu = \kappa (411), \pi = \kappa (611), \phi = \kappa (911), z = \kappa (16\ 1\ 1), b = \kappa (332),$$

$$e = \kappa (552), \text{ the last six forms being slightly exaggerated in size.}$$

NOTE.—Subsequent to the reading of this paper, the author found that the same subject had been treated by Baumbauer in an interesting investigation under the title "Distinct hemihedral Binnite crystals" (*Zeitschr. f. Kryst.* xxi. p. 202, 1893). He has been led to accept the hemihedral nature of the mineral from the examination of six crystals which exhibited a similar distribution of the forms and similar physical differences in the faces to those described above. Of forms not hitherto recognised, he announces—

$$\kappa (433) + \frac{40\frac{1}{2}}{2}$$

$$\kappa (322) + \frac{30\frac{3}{2}}{2}$$

$$\kappa (19.6.6) + \frac{130\frac{1}{2}}{2}$$

¹ *Bihang t. Svenska Vet.-Akad. Handl.*, 1887, Vol. 13, and *Zeitschr. f. Kryst.* XV., 84.

Notes on the optical characters of the Globules and Spherulites of Lithium Phosphate and some other salts.

By Lieut. General C. A. McMAHON, F.G.S.

(With Plate V.)

[Read April 18th, 1893.]

IN my paper "On the Micro-chemical Analysis of Rock Making Minerals,"¹ I noticed the abnormal behaviour of globules of lithium phosphate $\text{Li}_3\text{PO}_4 + \text{H}_2\text{O}$ in polarised light; the dark cross which ought to remain fixed when the globule is revolved between crossed nicols, opening up, in some cases, into two hyperbolic branches like those of a biaxial crystal in converging polarised light. I find that similar anomalous results may be obtained from the globules yielded by other salts; for example those of the double sulphates of beryllium and potassium $\text{BeSO}_4\text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$, and of lithium and sodium (LiNaSO_4).

Some substances, as for instance granules of starch, present a dark cross when examined under the microscope between crossed nicols, which is explained by the action of the onion-like skins of which the grains are built up upon the rays of light transmitted through them, but this explanation does not apply to the globules under consideration, as there is no reason to suppose that they possess this structure, and if they did it would not explain the opening up of the cross.

Secondly. The peculiarity under discussion does not depend on twinning, to which cause I was at first disposed to attribute it. The opening out of the dark cross appears in some individuals which do not exhibit any trace of twinning; and even in those which seem to be twinned, the opening out of the cross does not bear any fixed relation to the plane of twinning.

Thirdly. It does not appear to be connected with the growth of a globule from two or more different centres. If these centres were so close together that the eye, even aided by the microscope, could not

¹ *Min. Mag.*, Vol X. p. 79.

divide them, the globule would behave as a single individual, and, for a practical purposes, it would have to be regarded as having originated from a single centre. In cases in which the two centres of growth are sufficiently wide apart for the eye to take cognisance of the distance between them, one can readily see that the globule is compounded of two individuals joined together. For instance, in fig. 1, Plate V., a globule is depicted which has originated from two centres near each other. Both halves are normal. A thin line of light intervenes between the two halves, and the perpendicular arm of the cross is seen to be twice its normal thickness. We have here two crosses (not a single one) the perpendicular arms of which are parallel to each other. At fig. 2 we have a compound globule made up of two individuals whose centres of growth are somewhat distant from each other. In this case one half is normal (nearly showing a *fixed* cross) and the other is abnormal; that is to say, the cross opens up, when revolved between crossed nicols, into hyperbolic branches. At fig. 3 a compound globule is shown, both halves of which are abnormal. Figs. 1 to 3 (and such instances are numerous) sufficiently show that the phenomenon of the opening out of the cross into hyperbolic branches does not depend on the linking of two globules together. Many globules that exhibit the opening out of the cross are single, and not compound globules, whilst strings of linked globules may be seen in which every member is normal. An instance is shown in the upper part of fig. 12.

Fourthly. The phenomenon is not due to the overlapping of one disk upon another. The effects due to overlapping are illustrated in figs. 4 and 5. We have distortion, but not of the character seen in abnormal globules. In fig. 4 two normal disks have overlapped. In fig. 5 we have one normal and one abnormal disk overlapping.

Fifthly. I have come to the conclusion that the phenomenon above described is really due to molecular strains at the time of crystallisation.

Spherulites are, it is well known, made up of fibrous crystals radiating from a centre. In cases in which each individual crystal has straight extinction a cross is formed, each arm of which corresponds to the plane of one of the crossed nicols, and the cross remains fixed when the spherulite is revolved. In many cases this structure is doubtless present in the globules under consideration, and to it is due, in such cases, the fixed black cross when the globule is revolved between crossed nicols. Sometimes this radiating fibrous structure can be actually made out in the globules by the use of high powers, and they fall within the definition of a spherulite; at other times this structure cannot be seen, and it

presence, or the presence of an analogous structure to be presently described, must be inferred from the appearance of the black cross between crossed nicols.

In the spherulite each radiating crystal has length without width; that is to say, the width is inconsiderable as compared with its length. The amount of width in each individual is made up for by the number of the individuals. But this arrangement does not always prevail in the rounded crystal aggregates under description. In such a crystal aggregate it is not necessary that each radiating crystal should be a fibre—that it should be without sensible width. Individual crystals may be increased in the direction of their width, and they may be comparatively few in number. A spherulite made up of a set of crystals in the form shown in fig. 6, would show a fixed dark cross if each crystal extinguished parallel light at right angles to a line radiating from the centre of the spherulite that divided the crystal into two halves.

Fig. 11 is a sketch of a spherulite of lithium phosphate under crossed nicols. It is made up of radiating crystals that possess considerable width at the circumference of the spherulite; and on being revolved the cross opens up as shown at fig. 11; that is to say, with the exception of a thin dark line in the centre, the cross opens out very much in the case of the abnormal spherulites. On a single slide I have numerous other instances almost precisely similar in character, and I think the explanation they suggest is that the opening up of the cross is due to strain. The strained crystals are not absolutely uniform throughout, as far as their optical characters go, and when revolved between crossed nicols the lines of extinction are wavy and irregular and remind the observer forcibly of the well known phenomena of "strain shadows."

That the abnormal appearances discussed above are due to strains at the time of crystallisation may, I think, be seen on an examination of many of the compound rounded crystals of lithium phosphate. In figs. 10, and 12, I have sketched a few illustrations. Rounded compound crystals of a salt, having, presumably, the same chemical composition as lithium phosphate, have grouped themselves round small normal globules of that salt. The small endogenous globules are rarely in the centre of the larger spherulites that surround them, and this, or some other cause not apparent, has set up a condition of strain, the consequence of which is that the cross seen between crossed nicols is very irregular, as represented in the illustrations (figs. 9, 10, and 12). Again the elongated or oval globules of the double sulphate of beryllium and potassium ($\text{BeSO}_4\text{K}_2\text{SO}_4 + 2\text{H}_2\text{O}$) the cross opens up (fig. 13) in a way

that has a definite and fixed relation to the direction of elongation, and appears to point to a condition of strain. Here the molecular tension that caused the strain was presumably connected with the elongated shape of the globules. Nearly all the elongated globules open up the dark cross, and those that exhibit this phenomenon invariably open up into two hyperbolic branches approximately parallel to the longer axis of the crystal, as shown in fig. 13. Sometimes the lozenge shaped globules are united in the form of a star (embryonic rhombs), as shown in fig. 14. This star gives a dark cross between crossed nicols, each arm of which runs down the centre of each lozenge. On the star being revolved 45° the cross opens out and disappears.

In the spherulites yielded by lithium sodium sulphate (LiNaSO_4) different conditions prevail. Some of these spherulites, when examined under crossed nicols, are seen to be compounded of two portions with optical and structural differences between them. One portion, which does not possess a fibrous structure, shows an inner bright cross (a, b, c, d , fig. 15) when the planes of the crossed nicols are at 45° to the arms of the cross, as shown in the illustration. (N^1N^1 and N^2N^2 represent the crossed nicols.) Now if a quartz wedge be inserted parallel to (c, d) the phenomenon of thinning will be *simultaneously* produced in all four arms of the cross, showing that the doubly refracting cross (a, b, c, d) is not produced by two crystals (a, b) and (c, d) crossing each other; or by four crystals, possessing straight extinction, radiating from a common centre. If either of these two cases represented the structure of the cross the quartz wedge, when introduced parallel to (c, d), would produce the phenomenon of thinning in two of the arms of the cross (such as (a) and (b) for example), and the phenomenon of thickening in the other two arms (as (c) and (d) for example). The four arms of the cross (a, b, c, d), therefore, belong to one and the same crystal face, and the extension of this face over the whole area of the spherulite has been prevented by the interposition of *fibrous* crystals at e, f, g, h , that follow the ordinary spherulitic structure; that is to say, they radiate from the centre and show the phenomenon of thinning with the quartz wedge either parallel to, or at right angles to, the fibres, and not simultaneously in both directions.

In the case represented by the illustration, fig. 15, the face (probably the basal face) which forms the cross a, b, c, d , is elongated in two directions at right angles to each other; but there seems no reason why the elongation should not sometimes be in one direction only and at other times in more than two directions; or why those elongations of the base

should not take place in azimuths other than those in which the elongation has taken place in the case depicted at fig. 15. Further, there seems no reason why the radiating fibrous crystals, which in fig. 15 are represented as interposing at *e*, *f*, *g*, and *h*, should not accommodate themselves to the developments, or elongations, of the basal plane, and interpose sometimes at one azimuth, and sometimes at another; or why they should be unduly represented on some occasions and scarcely represented at other occasions. Illustrations of all these variations may be seen in some or other of these spherulites. For instance, lithium sodium phosphate (LiNaSO_4) belongs to the hexagonal system, but the spherulites of this salt exhibit what is at first sight a very puzzling appearance. Between crossed nicols some are all dark; some exhibit a regular black cross with four arms; some show five, six, or more than six arms. In some instances the arms radiate in a north, south, east, and west directions; in others they radiate irregularly at different azimuths. At the first blush the observer might easily fancy that he was dealing with the intergrowths of a monoclinic and of a hexagonal mineral. The true explanation, I think, is that offered above; namely, that we have sometimes irregular elongations of the basal face at various azimuths interrupted by radiating fibrous crystals lying on one of the pinacoidal faces: and, in short, the combinations presented are a form of twinning.

Fergusonite from Ceylon.

By G. T. PRIOR, M.A.

[Read April 18th, 1893.]

IN the appendix to the paper on the new mineral, baddeleyite, in the last number of the Magazine, Mr. Fletcher proves the identity of the mineral with the brazilite of Hussak, and explains the deviation in specific gravity and the original incorrect determination of the chemical composition of the Brazilian mineral by the supposition that the crystallographic measurements were made on the true mineral, while the specific gravity determination and chemical analysis were made on another tantalum-niobate of yttrium associated with it. This idea was supported by the fact that the baddeleyite from Ceylon was found in association with a so-called yttrotantalite, having very approximately the same specific gravity as that first attributed to brazilite. It is this mineral which is the subject of the present communication. Since its specific gravity (about 5) was some way below the lower limit for yttrotantalite, complete quantitative analysis seemed desirable in order to determine its true nature. The specimen analysed was one of seven rounded pieces from the gem mines at Rakwana, Ceylon, which were presented to the British Museum collection by Mr. Joseph Baddeley. Of these specimens the three largest had approximately the same specific gravity, about 5; in one of the other pieces the specific gravity was as high as 5.49, and another as low as 4.54. Of the remaining pieces, one turned out to be tourmaline and the other a spinel. The specimen from which material was taken for analysis was, like the others, a rounded pebble showing signs of crystal faces. The specific gravity of the whole specimen weighing 10 grms., by hydrostatic weighing, was 4.950; that of carefully selected material for analysis in small fragments, by pyknometer, 5.023. Hardness 5-6. Very brittle. The lustre is vitreous to sub-metallic on the surface of fracture, which is conchoidal and brilliant. There is no clearly marked cleavage. The colour is very dark brown to black, and in fine powder pale brown. Thin splinters are translucent and bright yellowish brown in colour. The mineral is isotropic. I

usable. Fragments heated in the closed tube decrepitate very slightly, and give off water which has a slightly acid reaction, so that the mineral all probability contains traces of fluorine, though I have not attempted to determine the amount. The phenomenon of glowing was not observed. The mineral was completely soluble with some little difficulty in the microcosmic acid, which in the inner flame was reddish yellow when hot, colourless and very faintly green when cold. The mineral was decomposed to some extent when heated with hydrochloric acid.

The results of the two analyses are given in Columns I. and II., while in Column III. is added, for the sake of comparison, an analysis by Rammelsberg of a brown Fergusonite from Ytterby.

	I.	II.	III.
Nb_2O_5 } 49.82		44.65	40.16
Ta_2O_5 }		4.98	8.78
UO_3 } 4.98		5.11	1.98
UO_2 }			
Y_2O_3 } 39.84		24.67 { atomic weight	38.26
Er_2O_3 }		13.24 { 112	
CaO }		2.02	8.40
Fe_2O_3 0.50		0.51	8.09(FeO)
H_2O		4.58	4.47
F ?			WO_3 } 0.91
			SnO_2 }
		99.76	101.00
G = 5.023			G = 5.056

Weight of material used in analysis I., 1.1064 grm., in analysis II., 0.254 grm.

In No. I. the method of Lawrence Smith (Original Researches in *Philosophical Magazine*, and *Chem. News*, XLVIII., 13, 29, and *Am. Chem. Soc. Trans.* V., 44 and 73) was followed, *i.e.* the very finely powdered mineral was decomposed by strong hydrofluoric acid. The action of the acid in the case of samarskite was not very energetic, and complete decomposition had to be effected by warming at about 70° , evaporating nearly to dryness, and renewing the acid once or twice. In the case of samarskite Lawrence Smith states that the decomposition takes place as readily as that of calcite in dilute acids. The filtrate containing the metallic acids also contained about half of the uranium, so that this element was present in the mineral as UO_3 and as UO_2 . The insoluble fluorides were decomposed by H_2O_2 , and all the earths precipitated by ammonium oxalate. The attempt

to separate members of the cerium group by means of K_2SO_4 and also Na_2SO_4 was repeated several times, but no appreciable precipitate was obtained. The iron and uranium were separated in the usual way by means of ammonium carbonate and ammonium sulphide. Before precipitating the uranium it was found to be absolutely necessary to evaporate and expel the ammonium salts.

In the second more complete analysis the old method of fusion with $KHSO_4$ was resorted to. The separation of the niobic and tantalic acids was effected by Marignac's method (*Ann. Chim. Phys.* VIII. (1886), 60) but as far as my experience of the method goes I can only consider the result as approximately correct. In the filtrate from the metallic acids the earths were precipitated twice by $AmOH$, and the calcium in the filtrate was thrown down by $Am_2C_2O_4$.

The ammonia precipitate of the earths was redissolved, and the yttria etc., precipitated by oxalic acid. The atomic weight was determined the usual way by conversion of the oxides into sulphates, and the relative proportion of the yttria and erbia was deduced from the formula of Bahr and Bunsen. The presence of erbia was indicated by the decided pink colour of the salts.

Owing to the lack of crystalline form and the isotropic nature of the mineral the crystallographic and optical properties could not be determined but the result of the analysis can leave no doubt that it should be referred to Fergusonite. In specific gravity and chemical composition it stands very close to one of the brown Fergusonites from Ytterby, the analysis of which is given in column III. In all external characters also, lustre, colour, etc., it closely resembles the Fergusonites from Ytterby in the British Museum collection with which I have compared it.

In their paper on yttria and thoria minerals from Llano Co., Texas (*Am. J. Sci.*, 38, 482), Hidden and Mackintosh give analyses and descriptions of two varieties of Fergusonite. One with specific gravity 5.67 and containing about 2 per cent. of water they distinguish as monohydrated; the other with specific gravity 4.36-4.48 and containing much as 8 per cent. of water, as tri-hydrated Fergusonite. The first variety decrepitated when heated and exhibited the phenomenon of glowing, changing at the same time to a pale olive green colour. The other variety did not decrepitate nor show signs of glowing. The authors consider that the name Fergusonite should be reserved for the anhydrous mineral, and that the various definite hydrated varieties should be distinguished as mono-di- and tri-hydrated. To the di-hydrated variety they refer the brown and yellow minerals from Ytterby, which were

originally regarded as yttrotantalite until Rammelsberg (*Ber. Akad., Berlin*, 1871, 406) showed that they must be referred to Fergusonite.

From its specific gravity, chemical composition and percentage of water, the specimen which I have analysed naturally falls into this same class, and must be considered as a di-hydrated Fergusonite.

But it is very probable that amongst the specimens received from Mr. Addeley we have examples of both the other varieties described by Hidden and Mackintosh. Thus the specimen with higher specific gravity (5.49) answers closely to the description of their mono-hydrated Fergusonite with specific gravity 5.67. Heated in the tube it decrepitates, though not very strongly, and the phenomenon of glowing is very pronounced even in small splinters; just at the point of redness a small fragment suddenly appears to take fire, and a bright red glow spreads rapidly through it. It is lighter in colour and more distinctly brown than the specimen analysed, and the fracture was not so brilliant and more resinous; in thin splinters it was rather more opaque, but of the same light yellowish brown colour. Qualitative examination showed that it contained niobic acid (blue colour with Sn and HCl) and yttria earths. The specimen with lower specific gravity (4.54) was very similar in appearance, but more transparent in thin splinters than either of the other two. It so far behaved like the tri-hydrated variety of Hidden and Mackintosh, that it did not decrepitate on heating nor show signs of glowing.

The phenomenon of glowing, which some of these minerals possess in common with so many specimens of gadolinite, was, I believe, first pointed out by Lawrence Smith in 1877 (*Am. J. Sci.* 13, 367) in a Fergusonite from Rockport, in which it was exhibited, he states, in a more striking manner than in any specimen of gadolinite with which he had experimented. In the case of gadolinite the connection between the phenomenon and the isotropic character of the majority of specimens of this mineral has been pointed out by Petersson. He has shown (*Geol. Fören. Stockholm, Verhandl.* Bd. XII., p. 275) that in most localities the original gadolinite has been more or less converted by a paramorphic change into an amorphous and isotropic mineral. Both the anisotropic and isotropic varieties have the same chemical composition, but the latter has resulted from the former by a molecular re-arrangement. By the action of heat both varieties rose in specific gravity, and no longer gelatinised with HCl, but an interesting point is that the isotropic and amorphous variety becomes doubly refracting, the conversion into the anisotropic form being accompanied by a development of light and heat as exhibited in the phenomenon of glowing.

I find that these specimens of Fergusonite exhibit precisely similar phenomena. All the specimens after heating to redness become doubly refracting. In the specimen with the highest specific gravity which exhibits the phenomenon of glowing, and is less translucent with a dull fracture, the amorphous change from an original anisotropic mineral has no doubt proceeded furthest. In the specimen analysed, although no glowing could be observed, yet the conversion of the isotropic material into anisotropic was well marked: splinters which, before heating, were quite isotropic became rather more opaque, but strongly doubly refracting; and in one flake a tolerably distinct uniaxial figure in convergent light was observed. In the specimen with lowest specific gravity the conversion into a doubly refracting form was equally distinct. According to Petersson there are only two localities in which anisotropic gadolinite is found, viz. Hitterö, Norway, and Stora Skedevi, Dalarne, Sweden.

Whether anisotropic Fergusonite exists anywhere I am unable to say for all the specimens belonging to the British Museum collection which I have examined proved to be isotropic. I find that the mineral from Greenland, the locality in which it was originally discovered by Giesecke, decrepitates when heated, exhibits the phenomenon of glowing perhaps more strikingly than any of the others, and becomes doubly refracting. The brown Fergusonite from Ytterby decrepitates and becomes doubly refracting, but does not glow.

The actual phenomenon of glowing appears to be connected with the degree of hydration; since, as far as the evidence goes at present, it is confined to the anhydrous and mono-hydrated Fergusonite, for the specimens in which I have observed it have specific gravities respectively of 5.5 and 5.8, while the specific gravity of the Fergusonite in which it is noted by Hidden and Mackintosh is 5.67, and that of the specimen described by Lawrence Smith is 5.68.

Extinction-Angles in Cleavage-Flakes.

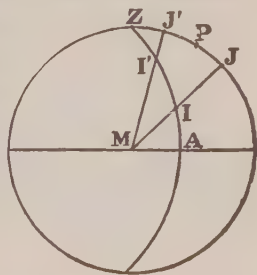
By ALFRED HARKER, M.A., F.G.S.

[Read April 18th, 1893.]

NOW that the measurement of extinction-angles in cleavage-flakes is frequently used to assist in the identification of minerals, the question of the relation of angles so measured to the orientation of the optic axes is one that must frequently arise. I confine myself here to the case of monomineralic minerals, such as hornblende and augite, in which the optic axes are parallel to the clinopinacoid and the cleavage is prismatic.

To obtain the requisite trigonometrical relations, project for convenience on a prism-plane M , and let I and I' be the positions of the optic axes; that $ZI = \alpha + V$ and $ZI' = \alpha - V$, where α is the extinction-angle in a clinopinacoidal section and $2V$ the angle between the optic axes.

Now for a given wave-front the two possible planes of vibration bisect the angles between the two planes drawn through the normal and the two optic axes severally.¹ Hence, if the great circles MI and MI' meet the circle of projection in J and J' , and the arc JJ' be projected in P , ZP is the extinction-angle for a cleavage-flake. The right-angled triangle IJJ' gives the relation



$$\tan ZJ = \cos IZJ. \tan ZI = \sin \phi \tan (\alpha + V),$$

where $\phi = MA$, or half the cleavage-angle. Similarly

$$\tan ZJ' = \sin \phi \tan (\alpha - V),$$

and since

$$ZP = \frac{1}{2} (ZJ + ZJ'),$$

extinction-angle in a cleavage-flake is thus determined as depending on α and V .

The following tables for hornblende and augite are calculated from the

¹ See (e.g.) Fletcher, *Min. Mag.* (1891), Vol. IX., p. 341.

above relations. They give, to the nearest quarter of a degree, the extinction-angle in a cleavage-flake as depending on α , the extinction angle in a clinopinacoidal section, and $2V$, the true angle between the optic axes. The cleavage-angles are taken from Miller : $2\phi = 55^\circ 30'$ for hornblende and $92^\circ 54'$ for augite. In the case of augite the two directions of extinction are supposed to be discriminated: if this be not done, an ambiguity arises between an angle over 45° and its complementary angle.

HORNBLLENDE.

For Values of α .	For Values of $2V$.					
	40°.	50°.	60°.	70°.	80°.	90°.
4	2	2	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	3
5	2 $\frac{1}{2}$	2 $\frac{1}{2}$	3	3 $\frac{1}{4}$	3 $\frac{1}{2}$	3 $\frac{3}{4}$
6	3	3 $\frac{1}{4}$	3 $\frac{1}{2}$	3 $\frac{3}{4}$	4 $\frac{1}{4}$	4 $\frac{1}{2}$
7	3 $\frac{1}{2}$	3 $\frac{3}{4}$	4	4 $\frac{1}{2}$	4 $\frac{3}{4}$	5 $\frac{1}{2}$
8	4	4 $\frac{1}{4}$	4 $\frac{3}{4}$	5	5 $\frac{1}{2}$	6 $\frac{1}{4}$
9	4 $\frac{1}{2}$	5	5 $\frac{1}{4}$	5 $\frac{3}{4}$	6 $\frac{1}{2}$	7
10	5 $\frac{1}{2}$	5 $\frac{1}{2}$	6	6 $\frac{1}{4}$	7	7 $\frac{3}{4}$
11	5 $\frac{3}{4}$	6	6 $\frac{1}{2}$	7	7 $\frac{3}{4}$	8 $\frac{1}{2}$
12	6 $\frac{1}{4}$	6 $\frac{1}{2}$	7	7 $\frac{3}{4}$	8 $\frac{1}{2}$	9 $\frac{1}{4}$
13	6 $\frac{3}{4}$	7 $\frac{1}{4}$	7 $\frac{3}{4}$	8 $\frac{1}{4}$	9 $\frac{1}{4}$	10 $\frac{1}{4}$
14	7 $\frac{1}{4}$	7 $\frac{3}{4}$	8 $\frac{1}{4}$	9	9 $\frac{3}{4}$	11 $\frac{1}{4}$
15	8	8 $\frac{1}{4}$	9	9 $\frac{3}{4}$	10 $\frac{3}{4}$	12
16	8 $\frac{1}{2}$	9	9 $\frac{1}{2}$	10 $\frac{1}{2}$	11 $\frac{1}{2}$	12 $\frac{3}{4}$
17	9	9 $\frac{1}{2}$	10 $\frac{1}{4}$	11	12 $\frac{1}{4}$	13 $\frac{3}{4}$
18	9 $\frac{1}{2}$	10	11	11 $\frac{3}{4}$	13	14 $\frac{1}{4}$
19	10	10 $\frac{3}{4}$	11 $\frac{1}{2}$	12 $\frac{1}{2}$	13 $\frac{3}{4}$	15 $\frac{1}{2}$
20	10 $\frac{1}{2}$	11 $\frac{1}{4}$	12 $\frac{1}{4}$	13 $\frac{1}{4}$	14 $\frac{3}{4}$	16 $\frac{1}{4}$

AUGITE.

For Values of α .	For Values of $2V$.		
	50°.	60°.	70°.
38	32 $\frac{1}{4}$	33 $\frac{1}{4}$	34 $\frac{1}{4}$
39	33	34	35 $\frac{1}{2}$
40	34 $\frac{1}{4}$	35 $\frac{1}{4}$	36 $\frac{1}{2}$
41	35	36	37 $\frac{1}{2}$
42	36	37	38 $\frac{1}{2}$
43	37	38	39 $\frac{1}{2}$
44	38	39 $\frac{1}{4}$	40 $\frac{1}{2}$
45	39	40 $\frac{1}{4}$	41 $\frac{1}{2}$
46	40	41 $\frac{1}{2}$	42 $\frac{1}{2}$
47	41	42 $\frac{1}{4}$	44
48	42	43 $\frac{1}{4}$	45
49	43 $\frac{1}{4}$	44 $\frac{1}{2}$	46
50	44 $\frac{1}{4}$	45 $\frac{1}{2}$	47
51	45 $\frac{1}{4}$	46 $\frac{1}{2}$	48
52	46 $\frac{1}{4}$	47 $\frac{1}{2}$	49
53	47 $\frac{1}{4}$	48 $\frac{1}{2}$	50 $\frac{1}{2}$
54	48 $\frac{1}{4}$	49 $\frac{1}{2}$	51 $\frac{1}{2}$

It will be noticed that the figures for different values of $2V$ do not differ very widely. It would be impossible to determine $2V$ with any accuracy by combining observations of extinction-angles in a cleavage-flake and clinopinacoidal section.

On the mode of occurrence of Gold.

By HENRY LOUIS, A.R.S.M., F.I.C., F.G.S.,

Mem. Amer. Inst. Min. Eng., etc.

[Read April 18th, 1893.]

IN the present paper an attempt will be made to summarise known facts respecting the mode of occurrence of gold in its matrix, and to draw certain inferences from these facts as to the manner in which the gold has been deposited. The general opinion of miners that it has been introduced by igneous action, in a state of either fusion or volatilisation, does not agree with modern theories of the origin of metalliferous veins, which ascribe their existence to hydrothermal action, or at any rate suppose the metals to have been introduced in aqueous solution.

The deposition of the definite crystalline mineral gold alone will be dealt with, excluding the occurrence of gold more or less intimately combined with tellurides, sulphides, etc.: or, to use the gold miner's expression, "free reef-gold" will alone be considered.

A study of the paragenesis of gold seems to be the best method of approaching the subject. The following table accordingly gives as complete a list as possible of all minerals known to the author as ever occurring with gold in the same deposit, although it cannot be supposed that their deposition was in all cases contemporaneous with that of the gold. The author wishes to acknowledge with thanks the valuable assistance received from Mr. H. A. Miers in compiling this list. All those minerals which may be looked upon as common in auriferous deposits are distinguished by full type.

LIST OF MINERALS.

I.—NON-METALLIC MINERALS.

MINERALS.

LOCALITIES.

Quartz
Clays
Chlorite

Mica	
Serpentine	Russia
Orthoclase	Colorado
Garnet (Grossularia, Siam)	
Calcite	
Dolomite	California, Transylvania
Magnesite	Australia
Aragonite	New Zealand
Apatite	Ottawa
Fluorite	
Selenite	
Tourmaline	
Hornblende	
Prehnite	Craddock, Cape Colony
Pyrophyllite	Beresovsk
Sulphur	"
Barytes	
Lignite	Transylvania

II.—METALLIC MINERALS.

MINERALS.	LOCALITIES.
Iron Pyrites	
Mispickel	
Löllingite	Idaho
Copper Pyrites	
Erubescite	Beresovsk
Covellite	
Redruthite	
Stibnite	
Galena	
Zinc Blende	
Cinnabar	
Bournonite	
Tetrahedrite	California
Pyrargyrite	
Molybdenite	
Tetradymite	Hungary
Argentite	Siberia
Aikenite	
Stromeyerite	Siberia

Clausthalite	Harz
Hessite	Transylvania
Melonite	California
Ilmenite	
Magnetite	
Hæmatite	
Limonite	
Siderite	
Vivianite	Victoria
Manganese Blende	Transylvania
Rhodochrosite	"
Bustamite	Mexico
Pyrolusite	
Wad (?)	
Chrysocolla	Namaqualand
Malachite	Beresovsk, etc.
Azurite	"
Wolfram	Victoria
Scheelite	Italy, Bohemia
Pyromorphite	Wales
Mimetite	Nevada
Crocoisite	Beresovsk
Melanothroite	"
Vanquelinite	"
Vanadinite	"
Cerussite	"
Anglesite	"
Cervantite	Victoria
Valentinite	"
Kermesite	"
Scorodite	Beresovsk
Jarosite	"
Bismutite	Pilgrim's Rest, Transvaal
Lead	Victoria
Bismuth	
Arsenic	
Silver	Mexico

The above list comprises no less than 77 species, and even then it is possible that a few of the rarer occurrences have been overlooked. Only

about 12 of these can be designated as plentiful in auriferous veins, the others being for the most part very rare. Many are secondary products arising from the decomposition of other, perhaps common, species; the presence is thus only due to the previous existence in the auriferous matrix of some of the common minerals which can alone, therefore, be looked upon as the original constituents of the vein matter.

Looked upon as a whole, this list strongly supports the hydrothermal as opposed to the igneous, theory of the origin of gold, as it does not contain a single mineral the introduction of which could not fairly be ascribed to hydrothermal action, whilst all that series of minerals which are characteristic of volcanic rocks is conspicuously absent.

Turning first to the non-metallic minerals, of which there are 20 species, only four of them, namely, quartz, clay, chlorite and calcite, can be set down as occurring at all commonly as constituents of auriferous veins.

Quartz is of course the usual, it may almost be said the universal, gangue of auriferous veins; the author does not remember ever to have come across any reef gold that was not accompanied by more or less quartz, and in by far the larger number of instances quartz may be looked upon as the sole veinstuff. Auriferous quartz veins may be of any type of vein: fissure, segregated or intercalated; there is of course no difficulty in accounting for the fact that the filling of these veins should consist of quartz, but the association of gold with it is too invariable to be accidental; and it seems reasonable to suppose *a priori* that the solvent which carried the quartz into the vein carried also the gold in solution at the same time.

Of all the other non-metallic minerals it may be said that they occur rather as secondary minerals filling up crevices than as integral parts of the vein.

Orthoclase, however, does occur as a true ingredient of the veinstuff in some parts of Colorado; although it is an important ingredient of many rocks which have an igneous origin, yet there are many instances of the occurrence of this mineral in veins, into which it has obviously been introduced in aqueous solution.

Calcite is usually a secondary mineral constituent, being often deposited upon the primary vein ingredients, as is well exemplified, for instance, in some of the Nova Scotian gold reefs, where it is found in the cavities of the reefs beautifully crystallised upon quartz, gold, arsenic pyrites and other minerals that constitute the veinstuff proper. It forms, however, at times an integral portion of the matrix, as, for instance, in the curious occurrences at Kabin, Siam, where the gangue consists of it

intimate mixture of calcite, quartz, common garnet and grossularia, forming apparently lenticular gash veins.

Clay, of course, is a universal concomitant of all veins, especially in schists, slates or shales, either as a "gouge" on the walls of the veins, or else filling up crevices in their body; its presence needs no explanation, and, as it has evidently been introduced subsequently to the formation of the vein, its occurrence is of no importance in the present connection.

Chlorite is plentiful in many gold-quartz veins; as a notable example may be cited the well known fissure veins at Moodies, near Kimberley, Transvaal, where the veinstuff consists largely of quartz veins coloured bright green by disseminated chlorite, the country rock being a much metamorphosed, highly chloritic schist.

Prehnite occurs with gold at Craddock, Cape Colony, and nowhere else so far as known. The author has not visited the locality, so unfortunately can say nothing of the nature of the deposit; he has, however, in his possession specimens from it, showing prehnite in well developed crystals.

Tourmaline is a frequent constituent of auriferous veins, but it is often noticeable that such portions of the vein as are richest in this mineral are poorest in gold, and *vice versa*. Mica is rare, and mostly occurs in gold veins traversing granite.

None of the remaining non-metallic minerals call for any especial notice; they are either salts of the alkaline earths, whose presence is easily intelligible as secondary products introduced into the vein in solution, either contemporaneously with, or subsequently to the deposition of the quartzose veinstuff, or else they are silicates, such as would naturally be expected to occur in veins traversing highly metamorphosed schistose strata, this being the usual condition under which gold-quartz occurs.

Sulphur is a very rare mineral in gold veins, being a secondary product, no doubt resulting from the decomposition of pyrites.

It may be said of all these non-metallic minerals, excepting quartz, that the most curious feature about their occurrence is not so much their presence in these veins, as rather their great rarity, especially when compared with their frequency in other metalliferous veins. Why, for instance, should fluorite be plentiful in lead and copper bearing veins, and scarcely ever occur in auriferous ones?

As regards, in the next place, the metallic minerals, a few are plentiful in all gold districts; others, again, are secondary products derived from, arising out of the decomposition of the former. Thus hæmatite, goethite, siderite and vivianite are oxidation products of iron pyrites,

pseudomorphs after which latter mineral are by no means rare. Cervantite, valentinite and kermesite are oxidation products of stibnite, which occurs in some of the Victorian gold fields, whilst a whole series of lead minerals have been produced by the decomposition of galena. Other minerals, again, are practically confined to one special district, and no doubt owe their existence in the auriferous veins to purely local causes, the reasons for which can but rarely be traced. Such, for instance, are those comprised in the series of lead chromates and other lead compounds found in the gold veins of Beresovsk.

The following are really the only metallic minerals that can be looked upon as ordinary constituents of auriferous quartz veins:—

Iron Pyrites	Arsenical Pyrites
Galena	Zinc Blende
Copper Pyrites	Stibnite
Titaniferous Iron Ore	Magnetite.

The two oxides of iron may possibly be oxidation products of the pyrites, but from the fact that they are plentiful in veins that carry but little pyrites, that they occur as well in depth as near the surface, and that they are thoroughly disseminated through and intimately commingled with the quartz of the vein, they must rather be regarded as true original constituents of the reef matter, derived in all probability directly from the metamorphosed country rocks.

Iron pyrites is an almost universal constituent of gold quartz veins. It is worthy of note that whilst cubical iron pyrites is thus very abundant, marcasite never seems to occur in a gold reef. The author has never seen any indications of its existence, not even pseudomorphs after it, which latter might reasonably be expected to occur, even if the readily decomposable mineral itself had been destroyed, seeing how abundant pseudomorphs after cubical pyrites are. It is not known under what conditions bisulphide of iron crystallises as marcasite, rather than as cubical pyrites, but whatever these may be, it is pretty clear that they are either unfavourable to the deposition of gold, or else that the solutions from which marcasite crystallises are incapable of dissolving gold. There do not even seem to be any authentic records of the occurrence of auriferous marcasite.

Seeing, then, that quartz containing magnetite and ilmenite, together with the few sulphides named above, form the regular matrix accompanying native reef-gold, it remains to be seen whether any consistent theory can be framed to account for this paragenesis. Although there are serious difficulties in the way of accepting any theory hitherto formulated, yet the

author would suggest, as the most rational view, that gold and quartz have been simultaneously introduced into veins in the form of alkaline solutions. That alkaline solutions are a ready solvent of quartz is of course well known, and so is the fact that many natural waters are alkaline. It is equally well known that alkaline solutions are capable of holding gold in solution in the form of aurates, and also that gold is attacked by fused alkalies in the presence of air or of an oxidising agent like fused nitre, alkaline aurates being produced. There is therefore no reason why alkaline solutions should not be able to carry gold in solution into the reefs in which it is now found; admitting this view, the deposition of the gold may be due to several causes. It may be the result of the same causes that led to the separation of the quartz from its solution, whatever these causes may have been: it may be a result of electrolysis; or it may be due to the action of the metallic sulphides, which are the all but universal concomitants of gold in reefs: or possibly again the same reducing agents that led to the deposition of these sulphides also caused the precipitation of the gold. It would thus be an open question whether the coexistence of gold and sulphides is an effect caused by the presence of the latter minerals, or whether both owe their existence to some other precipitant. The author has found experimentally that sulphides, such as galena and arsenopyrites, will precipitate gold from alkaline solutions—but it must be noted that in these experiments an alkaline chloride was always present in the solution, as would also probably be the case in natural waters. The presence of silver in all native gold is very difficult to explain, as there seems no reason why the solutions that contained gold should also have carried silver.

The above brief notes have been put together more in the hope of inducing a fuller investigation of these problems than with the pretence of having helped much towards their settlement. The author ventures to think, however, that the hypothesis here suggested that gold has been carried in nature in alkaline, rather than as a chloride in acid solutions, generally held, may be found worthy of consideration.

On the "Skin" of Agates.

By Professor HEDDLE and J. STUART THOMSON.

[Read October 24th, 1893.]

“ I BELIEVE that the green ‘Skin’ of Agates will prove to be celadonite and not delessite, as has been generally supposed. This is an extract from a paper by one of us, which was published in 1879 in the *Transactions of the Royal Society of Edinburgh*.

Quarrying for agates upon a large scale having been carried out for several weeks during a succession of years on the shore of Forfarshire, an unusual supply of the soft coating which frequently invests them was obtained.

It is by no means insisted that this coating is invariably one and the same substance. At several, if not at many localities there is indeed no investing layer whatever. At others it is zeolitic-natrolite or crockalite; then it penetrates into the outer layers of the agate itself, and is not merely adherent, like the skin of a potato. The substance treated of in this communication is of a vivid green colour, is glossy upon its outer surface, and is disposed in layers, assuming occasionally internally a distinct, though minute mamillated structure. It is well seen on the agates of Scurr Hill in Fife, of the Path of Condry in the Ochils, and at the locality whence our supply was obtained,—the so-called “Blue Hole” near Usan, in Forfarshire.

The circumstances under which agates were formed, and also the minerals whose decomposition led to their formation, must vary much, and this they do irrespective of proximity of locality.

The agates of Scurdy Ness, which is not over three miles north of the Blue Hole, have no skin; while the skin of agates taken from a bed overlying that which yields the green coated agates of the “Blue Hole,” is russet brown, earthy, and may be removed by washing.

Again, the form of the agates of that upper bed is most irregular, even *hackly*, while that of the lower or true bed is ovoidal and smooth surfaced. The colours of the upper bed agates are reds, pinks and warm yellows; of the lower bed inky blues, with rarely outer layers of a rich

own jaspersy character. The substance of the upper bed stones, is in outer layers at least, more or less opaque, from that incipient water which produces "quartz-nectique." The lower bed stones are acid, sound, unaltered; but that which best characterises them is a brilliant smooth green coat, called in the district their "paint." This "paint" which was analysed.

Its specific gravity, taken on 48.5 grains, was found to be 2.605.

It yielded on analysis—

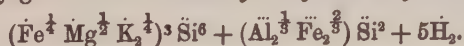
				Formula.
Silica	...	...	51.742	54.05
Alumina	...	...	4.448	8.88
Ferric Oxide	...	...	11.911	11.94
Ferrous Oxide	...	...	4.195	5.4
Manganous Oxide	...	...	trace	
Lime	...	...	0.585	
Magnesia	...	...	8.288	6.76
Potash	...	...	7.899	7.88
Soda	...	...	0.552	
Water	...	...	11.491	10.14

100.556

Of the above 11.491 per cent. water, 6.18 per cent. is lost at 212° Fah.;

5.716 is lost when the powder is exposed over H_2SO_4 , all being recovered on re-exposure to a normally moist atmosphere.

The figures in the second column give the numbers required by the formula already given in the *Edinburgh Royal Society Transactions*.



Celadonite is insoluble in acids. Now a small proportion of this substance in powder is soluble in acids. This, along with the slight difference in its composition from that of normal celadonite, warrants the supposition that there may be some little admixture with saponite or muscovite, both of which are decomposed by acids.

All the substances which by analysis have been shown to be celadonite decomposition products of transference,—not remaining within either the pores or the bounding walls of the decomposed or altered mineral, as a pseudomorphic plug. Hence we have no physical aid in conjecturing what mineral had been. Olivine, where present in the rock, yields serpentine or a more or less serpentine-like pseudomorph; and also probably yields the veins which cut both these pseudomorphs and such veins of the rock as are closely adjacent; but evidence that the de-

composition of olivine has yielded products which have been transferred into druses or interstitial spaces, has not been forthcoming.

Augite can be seen with its own rents filled with fibrous saponite, and also throwing out into drusy cavities plumose arrangements of piles of hexagonal crystals of saponite.¹

Hence, it is little more than the vaguest chemical speculation which would assign the formation of delessite, chlorophæite and celadonite also to the destruction of augite. In fact no mere degradation,—mere new arrangement of the ingredients pre-existent in any one of the minerals concerned—that is being altered—*rotted*, let us call it,—can form certain of these new compounds;—a re-combination of certain of the ingredients of several, or at least of more than one of these minerals, is necessary.

Olivine or enstatite could not supply the alumina,—augite could not supply the potash of celadonite; felspars must have been giving way, and when celadonite results, the presence of a potash felspar is almost vouched for.

It is at least clear that the changes which have taken place during the "alteration" of a rock,—the kaolinisation of its felspars—the serpentinisation of its enstatites and olivines—the lining of its cavities with zeolites and plugging them with agates—the details of the work in Nature's laboratory, in short—are not confined to the mere sundering of old combinations and their degradation through the loosening of the bricks, but are engaged also in the *elaboration* of new compounds and the building up of new structures,—in these cases more complex and more enduring than the originals which supplied their components.

To some small extent the rationale of the loosening of the bricks, and the consideration of the processes engaged in the sundering of the former structures has been entered upon; but those connected with the rearrangement of the materials, and the building up of the newer structures are still altogether beyond our ken.

It is, however, the first step towards knowledge to see clearly—to recognise what are the things which we do not understand.

¹ Usually set down as *serpentine* by petrologists.

REVIEW.

The Iron Ores of Great Britain and Ireland; their mode of occurrence, and origin, and the methods of searching for and working them; with a notice of some of the iron ores of Spain. By J. D. Kendall, F.G.S. London: Crosby Lockwood and Son, 1893, pp. xvi., 430.

This is a book for the miner rather than for the mineralogist. Its author is a practical man, who seems to have had experience in the examination and working of iron-ores in various parts of this country and Spain. It is, however, with the hæmatite deposits of the Whitehaven and Furness districts that he is specially acquainted.

Although hæmatite occurs to a limited extent in the Eskdale granite, the Skiddaw slate and in the Coniston limestone, it is in the carboniferous limestone series that all the more important ore-bodies are met. The writer describes the hæmatite deposits as being in some cases bed-like, and in others vein-like, whilst elsewhere they occupy dish-like hollows in the limestone, immediately below the drift, and finally in certain cases present forms of extreme irregularity. He believes that the hæmatite "is older than the lower Permian breccia, but younger than the bulk—if not the whole—of the coal-measures." The origin of the hæmatite is referred to a replacement of the limestone by ferric oxide, effected probably by the circulation of waters holding in solution ferric chloride. The chloride may have been of volcanic origin, since the formation of the hæmatite is traced to a geological period of much Mediterranean activity.

Viewed from a strictly scientific standpoint the volume offers much to which exception may be fairly taken. The mineralogist is not likely to look with favour upon a work so carelessly prepared that such an expression as "oxide of alumina" is allowed to recur page after page (*e.g.* pp. 211, 225, 244, 250).

Text-book of Petrology, containing a description of the Rock-forming Minerals and a synopsis of the chief types of Igneous Rocks. By F. H. Sturges, Ph.D., F.G.S. 8°, London, 1892, pp. vi. 222.

The appearance within a year of a second edition of this text-book of

petrology bears witness to the success which it has met with. The book has been carefully revised and enlarged to almost double its former size, the number of pages now amounting to 222 instead of 126, while the illustrations have been increased from 43 to 86. The general plan of the book, however, remains practically the same. After a general introduction follows a chapter describing the mode of occurrence of the igneous rocks, and here several new illustrations serve to more clearly explain the subject matter of the text. The method of classification adopted by the author is based chiefly upon chemical composition and mode of origin, while mineral composition is allowed to play only a secondary rôle. In the nomenclature the author mainly follows Rosenbusch and the German school of petrologists. In the last chapter the lists giving the distribution of the various rock types in the British Isles have been considerably enlarged, and several sketch maps showing the chief igneous masses in various districts have been added.

Altogether the additions which the author has made in the present edition appear to have greatly increased the scope and usefulness of the book.

Mineralogy. By F. H. Hatch, Ph.D., F.G.S., Whittaker's Library of Popular Science. London, 1892.

The little volume on Mineralogy which Dr. Hatch has contributed to Whittaker's Library of Popular Science appears to fairly well supply what is demanded of a popular introduction to the subject. The subject is a somewhat difficult one to present in an attractive and readable form in an elementary text-book of small compass; but the author, if not entirely successful in grappling with the difficulty, has made some advance in the right direction in the mode of treatment which he has adopted. Thus, in the first part of the book, dealing with the characters of minerals, he has wisely omitted those chapters on physical optics and chemistry which in the ordinary elementary text-book are often calculated rather to confuse than to enlighten the reader, and has confined his attention almost solely to the external characters, to that, in fact, which originally constituted the whole science of Mineralogy.

In the second part of the book, also, the method of classification made use of appears to be much better adapted to an elementary and popular text-book than the more strictly scientific chemico-crystallographic arrangement usually adopted. In the mode of classification here adopted the mineral species are divided into four groups:—(I.) The rock-forms

minerals. (II.) The ores with the veinstones accompanying them. (III.) The salts and useful minerals other than the ores. (IV.) The gems or precious stones.

This arrangement serves admirably to increase the interest in the subject by showing the connection between different mineral species as regards community of origin and mode of occurrence, and also by marking out those of economic importance which find their application in various industries.

Abstracts.

Mémoire sur diverses formes affectées par le réseau élémentaire du quar
 Michel Lévy and Munier-Chalmas. *Bull. Soc. Fr. Min.* Vol. XV. p.
 159-190. 4 Plates.

This paper is based to a large extent upon the examination, by L. Munier-Chalmas, of numerous varieties of concretionary silica forms upon the surfaces of gypsum in the Paris basin.

The paper opens with a brief historical sketch, in which, after citing the view held by DesCloizeaux in 1862, that chalcedony was an intimate admixture of crystalline and amorphous silica, or of quartz and opal, allusion is made to the opinions advanced by Rosenbusch, in which chalcedony is regarded as an optically uniaxial mineral, the optic axis lying in the direction of elongation, the double refraction and also the elongation of the fibres being negative, while the refractive index and the density are slightly less and the double refraction a little greater than that of quartz.

In 1889, one of the authors of the paper (M. Michel Lévy) pointed out that in many microscopic preparations of chalcedony and agate there were zones which always showed extinction, and in which the optical sign was always positive, the existence of an optic axis being shown in convergent light. On the other hand, he found that the fibres of the chalcedony were persistently negative in the direction of elongation. From this he concluded that chalcedony was a variety of quartz elongated perpendicular to the direction of a single optic axis.

This closes the introduction, and the paper then treats of these different forms of silica under the following heads:—Chalcedony, Quartzine and Lutécite.

Without entering into the very full details given in the paper, it may suffice to say that under the first of these heads CHALCEDONY is shown to be a fibrous optically biaxial mineral, the optic axes making a small angle about a positive bisectrix n_g or ϵ . The elementary fibres are extremely fine, each fibre being elongated in the direction n_p or α , and consequently being optically negative in the direction of elongation. The extinction is a rigorously parallel one. The terminations of the individual fibres are often very sharply pointed, but this is not always the case. Transverse sections of the fibres show no indication of crystalline faces or of measurable angles.

In some of the spherulitic forms of chalcedony it was found possible to determine approximately the angle of the optic axes, the real angle $2V$ being about 30° . The acute bisectrix is positive and perpendicular to the length of the fibres, to which the optic axial plane is always parallel.

The double refraction is found, as previously stated by Prof. Rosen-
sch, to be greater than that of quartz. As already stated, the length of the fibre coincides with n_p or a , and the transverse sections of the fibre contain n_g or c and n_m or b .

In the regularly zoned spherulites of chalcedony n_g and n_m are found not to occupy a fixed position throughout the length of any one of the constituent fibres, but to describe a helicoidal surface, the pitch of the spiral following the same law in each of the fibres. From this, as the authors remark, it may be seen "that any diametral plane will show a series of concentric zones having the same double refraction, from the zones perpendicular to n_g and nearly extinct, to the zones parallel to the optic axial plane and presenting a maximum of double refraction."

The authors consider it probable that chalcedony contains between its fibres a small amount of interstitial opal.

QUARTZINE.—This is described as a fibrous mineral, probably identical with chalcedony, and having the same properties save in its direction of elongation, which coincides with n_g or c , and is always positive. In convergent light quartzine is seen to be distinctly biaxial. The optic axes make a comparatively small angle: $2V = 35^\circ$. The extinction is strictly parallel to the direction of elongation. In quartzine no helicoidal shifting of the positions of n_p and n_m (such as that of n_g and n_m in chalcedony) has been observed, and the spherulitic and concretionary groupings are of a more simple type.

Quartzine sometimes forms tolerably straight bands, alternating with bands of chalcedony (Grisière, near Mâcon); at others it forms an internal coating to the more regular spherulites of chalcedony. Finally, quartzine may by itself constitute multiple zones of complex spheroids which towards the periphery graduate into a crystal of quartz, elongated along its single optic axis.

Delicate needles of quartzine in bundles interlaced at small angles become fused, as it were, into small crystals of quartz; but these latter occasionally show the exceedingly fine points of the quartzine needles, their grouped bundles sometimes exhibiting the same terminal angles as those of chalcedony, 78° to 105° .

The terminations of the quartz crystals also show subsequent concretionary investments of quartzine in fan-like arrangement.

The reciprocal action of orientation which the quartzine fibres are capable of exerting upon one another sometimes results in a grouping in which the central portion shows an optically positive uniaxial interference figure. A little away from the centre the dark cross breaks and two distinctly separated brushes appear, indicating the separation of optic axes about a positive bisectrix which emerges in the centre of the field. Still further from the centre of the group the bisectrix ceases to occupy the centre of the field. In each system of fibres the optic axial plane is perpendicular to the direction of apparent elongation (positive); but it must be remembered that the real elongation is parallel to n_g or c , which is a direction at right angles to that in which a plate showing the phenomena would lie. There is, therefore, in these fibrous bundles a relative flattening parallel to n_m or b .

The symmetry of the grouping is ternary, and it is seldom that an individual group occurs. It is more common to find many such groups inosculating.

LUTÉCITE.—This name has been given by the authors to a very peculiar grouping of fibres in which the optical orientation is quite distinct from that met with either in fibres of chalcedony or of quartzine, and to the fibres which constitute lutécite they have given the name lutécine.

The grouping of these fibres in lutécite is extremely complicated, and without the aid of the admirable diagrams with which the original memoir is plentifully illustrated it is scarcely possible to give an intelligible account. Suffice it to say that lutécite occurs in low bi-pyramidal hexagonal forms implanted upon the surfaces of crystals of quartz which enter into the constitution of spheroidal aggregates. Of the twelve faces those of two of the sectors differ from the remaining four, and the angle formed by the latter upon the basal edge sometimes attains 136° . No prismatic faces are present. Parallel grouping is common, and the crystals are seldom more than half a millimetre in diameter.

The fibres of lutécine which compose the crystals of lutécite give much more distinct appearances, both in parallel and convergent polarised light than those of either chalcedony or quartzine, and this not because the fibres are larger, but because they are more distinctly parallel.

The apparent elongation of the fibres is always optically positive, and in basal sections of lutécite the extinction in the fibres of the component lutécine is strictly parallel to this direction of elongation. The strength of the double refraction in such basal sections is about half that of quartz. In convergent light the interference figure of these fibres in a basal section

lutécite is suggestive of that of a uniaxial crystal, owing to the bisectrix lying outside the field of the microscope.

From further observations, however, the fact is established that fibres of lutécine are optically biaxial, and that the optic axes make an angle of not less than 35° about the bisectrix n_g or τ , and that the optic axial plane is situated at 29° from the direction of elongation of the fibres and at 74° from a senary axis, which latter bisects the right angles formed by the acute bisectrix n_g or τ , and the optic normal n_m or b .

In the résumé the authors point out that chalcedony, quartzine and lutécine are different forms of one and the same mineral, an optically positive biaxial mineral in which $2V$ ranges from 20° to 35° , and with a double refraction lying between 0.009 and 0.010.

The mineral consists of pure silica, having a specific gravity of about 2.65. It is essentially fibrous, and the fibres are susceptible of elongation in different directions, viz. n_p or α for chalcedony, n_g or τ for quartzine, and at 29° from n_g or τ in the plane $n_g n_m = b\tau$ (perpendicular to the plane of the optic axes), for lutécine.

The authors consider that chalcedony, quartzine and lutécine have in each case been derived from a primitive colloid condition of silica.

The most regular arrangement of the fibres of chalcedony gives rise to terulites with concentric zones which extinguish at regular intervals, and of which each fibre presents a modification of optical orientation in the form of a regularly advancing revolution of n_g and n_m ($= \tau$ and b) about $n_p = \alpha$.

The most regular arrangement of quartzine results in quartz by ternary aggregation about $n_g = \tau$, while the most regular arrangement of lutécine gives rise to lutécite by senary aggregation about an axis at 45° from $n_g = \tau$, and at 74° from the direction of elongation of the fibres in the plane $n_m n_g = b\tau$.

F. R.

On the Isomorphous Banding and Strength of the Double Refraction in Epidote. By Wilhelm Ramsay (Helsingfors). *N. Jahrb.* Vol. I. pt. 3 1898, p. 111. Extract in *Nachr. Ges. d. Wiss. Göttingen*, 1898, p. 167.

After referring to the observations of Klein, Michel Lévy, and Lacroix, the author states that the crystals which he examined were from Sulzbach, Zöptau, Arendal, Haddam, Traversella, Brosso and Ala; that some of them were simple, others twinned on (100), their optical orientation was $a = \bar{b}$, α deviating about 3° from c in the acute angle ($\hat{a} : c$), and in all the observed examples the absorption was $b > \tau > \alpha$. He finds that the variations in the double refraction and the peculiarities of structure are best

investigated in sodium light, between crossed nicols. A plate accompanying the paper, in which six sections $\parallel (010)$ and one $\parallel (100)$ are figured.

The structure and the strength of the double refraction in the nuclear portions and zonal envelopes of the crystals from the different localities already mentioned are then described in detail, and tables are given showing the observed values of $\gamma - \alpha$ in the different portions of the sections.

In conclusion, the author states that it is evident that a zonal structure consisting of a nucleus and isomorphous layers, is of common occurrence in epidote. The lack of homogeneity in this mineral usually reveals itself by interruptions in the growth of the crystal, and by changes in the chemical composition of the later-formed layers. Certain irregularities may be referred to a partial dissolving-up, or to mechanical disturbance during growth. The important fluctuations of the value $\gamma - \alpha$ in the same section, and furthermore in epidotes from different localities, are without doubt, caused in the first instance by changes in composition.

For the investigation of this relation new chemical analyses of optically tested material are necessary. Only in a single instance has the isomorphous banding of epidote been, hitherto, considered with reference to the analysis. In an epidote from Zöptau the dark nucleus and the clear envelope have been analysed separately (M. Bauer): the one contained 40 %, the other only 20 % of iron-silicate mixed with the alumina-silicate.

According to observations cited on p. 118 of the paper, the nucleus is more strongly doubly refracting than the clear layers which surround it. If one may consequently ascribe to the deep-green envelope of the epidote of Sulzbachthal a higher percentage of iron-silicate than to the brownish nucleus, then the strength of the double refraction increases with the percentage of iron. Thus, according to Michel Lévy, the strongest double refraction occurs in the epidote of Cabre in the coloured (0.056) the weakest (under 0.016) in the colourless portions. On comparing the epidotes from different localities it is found (roughly speaking) that a given relation exists between the colour, *i.e.* the percentage of iron-silicate and the strength of the double refraction.

Among the epidotes examined by the author, that of Traversella was found to have the deepest green colour and the greatest value for $\gamma - \alpha$, viz. 0.051. Then follow the epidotes of Arendal 0.051, and of Sulzbachthal 0.051. The crystals of Zöptau 0.043 and Haddam 0.035 are of paler colour. The epidote of Brosso 0.020 is of very clear colour, and that of A. 0.014 is almost colourless.

The assumption of an increase in the strength of double refraction with an increase of the iron-silicate does not appear to the author to contradict

the recorded analyses, while it also accounts for the very feeble double refraction of zoisite.

F. R.

Artificial Zircons, etc.—K. von Chrustchoff has devised a new apparatus for mineral synthesis from aqueous solutions by high temperature and intense pressure. The material is placed in a platinum tube surrounded by a steel cylinder, and, being hermetically enclosed with the aid of a screw, is heated by Bunsen burners. In one experiment the substances employed were gelatinous silica (obtained from crystallised sodium silicate by hydrochloric acid), gelatinous alumina (from the acetate), and gelatinous zirconium hydrate (precipitated from the solution of the chloride by ammonia). The heating was continued with increasing temperature for six days. The resulting product appeared in thin hexagonal plates, which, however, are not truly hexagonal unless there be optical anomalies. Extinction is parallel to a pair of faces of the hexagon. The specific gravity is 2·87, and the chemical composition :

SiO ₂	Al ₂ O ₃	ZrO ₂	H ₂ O	Total.
53·65	23·76	14·54	7·86	99·81

This does not correspond to any known natural mineral, but is a zirconia-bearing pyrophyllite.

In a second experiment gelatinous silica and gelatinous zirconium hydrate were heated for two hours with a twelve-fold Bunsen burner. The products were a clear fluid and a white solid, which latter when purified by hydrofluoric and hydrochloric acids gave colourless crystals of zircon agreeing closely with the theoretical composition. The forms present were (111), (221), (311), (101), (110), (100), while, according to their habit, the crystals may be divided into four groups:—(i.) the most numerous, simple (111) pyramids, “octahedral vesuvian type”; (ii.) a few long prisms, (111), (110), “granite type”; (iii.) modified short prisms; (iv.) with forms (111), (110), (100), “porphyry type”, similar to some crystals from the granite-porphyrries of Altenbach, etc. The forms (101), (221), and the ditetragonal pyramids were rare. The longest crystals reached about ·18 mm. (*Bull. Acad. Imp. Sci. St. Petersb.*, N.S. III., p. 343, 1892.)

A. H.

A Nosean-felspar-rock from Taimyr-land.—A remarkable rock-specimen, collected by Middendorff from the River Taimyr in Northern Siberia, has been described by K. von Chrustchoff (*Bull. Acad. Imp. Sci. St. Petersb.*, N.S. III., p. 421). The rock consists essentially of nosean and

felspar, and has a granitic structure, inclining to the ophitic, the felspar being moulded by the nosean.

	I.	II.
SiO ₂	64.59	37.83
Al ₂ O ₃	19.84	26.59
Fe ₂ O ₃	2.24	0.38
MgO	0.63	—
CaO	1.26	0.54
Na ₂ O	7.88	22.40
K ₂ O	8.58	1.63
H ₂ O	—	0.87
Cl	—	1.66
SO ₃	—	8.68
	99.97	99.68
Sp.gr.	2.572—2.602	2.666

The felspar is an anorthoclase, yielding the analysis I., which answers nearly to the formula $\text{Or}_2\text{Ab}_6\text{An}_1$. The extinction-angles are: on P (001) $+3^\circ 1'$, on M (010) $+7^\circ 4'$; and the birefringence $\alpha - \gamma = .0068$, in thallium light. The nosean is fresh and colourless, or with a yellowish tinge. Its inclusions have a zonary arrangement parallel to the face (110), (100), (111). Its composition is given in column II. The other constituents of the rock are brown hornblende (extinction-angle 14° , $\alpha - \gamma = .062$), brown biotite ($\alpha - \gamma = .055$, $2E = 20^\circ$, about), rare melanite and sphene, magnetite, large zircons (up to 1.63 mm. long showing faces (111), (110), (100), (311) with dominant prism-planes) and a little brown isotropic glass. The author names the rock-type "Taimyrite."

A. H.

Ancient volcanic rocks in Pennsylvania.—Numerous volcanic rocks of remote geological ages, but preserving in all essentials characters similar to those of the products of recent volcanoes, are well known to British geologists. Various reasons, chiefly of a theoretic nature, have prevented these from being widely recognised in other parts of the world. G. H. Williams expresses the opinion that such rocks will be found to occur at many points in the Appalachian region, and he has described some characteristic lavas from South Mountain in Pennsylvania and Maryland where they underlie strata carrying a Lower Cambrian fauna. Most observers in the district have mistaken these lavas for sedimentary rocks.

apparently on account of the cleavage with which many of them are affected. The majority of the rocks are rhyolites, usually porphyritic, and showing flow-structures, lithophysæ, spherulites, pumiceous modifications, &c. One specimen gave the analysis I.

	I.	II.	III.
SiO ₂	73·62	74·970	41·280
Al ₂ O ₃	12·22	13·860	18·480
Fe ₂ O ₃	2·08	—	9·440
FeO	4·03	2·700	8·200
MgO	0·26	1·230	7·486
CaO	0·34	0·220	7·040
Na ₂ O	3·57	not estd.	3·523
K ₂ O	2·57	not estd.	2·208
Ignition	0·40	2·058	2·740
	99·09	95·031	100·397

Another, crushed into a pale green fissile rock, gave the figures in column II. The porphyritic elements are quartz and an alkali-felspar, any ferro-magnesian mineral being very rare: the ground-mass is mostly a quartz-felspar mosaic, due to devitrification and recrystallisation, which, however, have not destroyed the characteristic structures of acid lavas. There are also basalts (analysis III.), which, though often preserving such original characters as the ophitic structure and porphyritic skeletons of olivine, are more weathered than the rhyolites, and also more frequently crushed into masses. In both types of lava epidote is a highly characteristic secondary mineral, and in the rhyolites the manganese-epidote (piedmontite) is widely distributed. With the lavas occur fragmental accumulations, viz. flow- and tuff-breccias, pumiceous bombs, and banded fine ashes. (*Amer. Journ. Sci.* XLIV. 482; 1892.)

A. H.

The Tin-ores of Bolivia.—Next to silver, tin is the most important metallic product of Bolivia, the annual yield being about 3,000 tons. According to A. W. Stelzner the tin-ores of the South American Cordilleras are restricted to a zone extending from the 15th to the 21st degree of latitude. In paragenesis and mode of occurrence they offer a remarkable contrast to the tin-ores of other countries. The ore is seldom in crystals, but usually crypto-crystalline, kidney-shaped, or compact. The usual tourmaline, topaz, fluor, apatite, etc., are almost entirely absent: instead of these the tin-ore is accompanied by stannine and other sulphides, such as silver-ores, fahlerz, pyrites, galena, and zinc-blende,

locally ullmanite and antimonite, wolfram, bismuth ores, and arsenical pyrites, besides quartz, barytes and carbonates. The tin-ore is intimately associated with the sulphides, occurring, for instance, as microlites enclosed in galena. Frequently the tin is restricted to the upper portion of a vein, its place being taken lower down by argentiferous fahlerz, pyrites, and locally galena and zinc-blende. In its geological occurrence, also, the tin-ore is remarkable, occurring in association, not with granite, but with trachytes and andesites referred to a late Cretaceous or early Tertiary age (*Zeits. d. deutsch. geol. Ges.* XLIV., p. 531; 1892). A. H.

H. Höfer (*Min. Mitth.* xii. 487) describes the crystallographic character of calcites from Rauris. He distinguishes six types, in all of which corrosion faces occur on the obtuse rhombohedron. Crystals on which there were crusts of stilbite showed a tendency to hemimorphic development. The author attributes this to the impurity of the solution from which the calcite crystallised, and points to the case of magnesium sulphate which from pure solutions crystallises holohedrally, but from solutions containing borax hemihedrally.

G. T. P.

A. Lacroix (*Comptes Rendus*, cxiv. 955) notes the relation existing between the form of the crystals of andalusite in Ariège and the nature of the formation in which they occur. He finds that they are absolutely characteristic one of the other, so that, given a crystal, it is possible to indicate the geological nature of the formation in which it was found.

G. T. P.

A. Schrauf (*Jahrb. Geol. Reich.* xli. 349) contributes an elaborate memoir on metacinnabarite from Idria, and its paragenesis. The mineral is cubic with dodecahedral habit, and the author concludes that it is isomorphous with zinc blende. It is supposed to have resulted partly by the direct action of H_2S upon native mercury, and partly by separation from solutions containing sulphuric acid, which is found to exercise a determining influence upon the separation of the black rather than the red sulphide.

G. T. P.

L. Bourgeois and H. Traube (*Bull. Soc. Fr. Min.* xv. 13) have obtained crystals of dolomite by a modification of their general synthetical process for the synthesis of carbonates. This process consists in heating to 130° in a sealed tube a mixture of a metallic salt, water and urea. With magnesium salts the method was not successful, owing to the solven

tion of the ammonium salt, formed during the reaction, upon the carbonate. By replacing the urea by potassium cyanate the production of ammonium chloride is reduced one half; and under these circumstances rhombohedra of dolomite were obtained which, like the natural mineral, were only slightly attacked by cold dilute hydrochloric acid.

L. Bourgeois (*Bull. Soc. Fr. Min.* xv. 194), by fusing metallic chlorides with titanous acid, has obtained a series of titanates isomorphous with pyrochlore. The titanate of manganese is identical with the recently described mineral pyrochlore. The magnesium titanate, which had been previously obtained by Hautefeuille, may possibly be identical with zirconolite.

G. T. P.

T. Lemberg (*Zeits. deutsch. geol. Ges.* xlv. 224), in a paper on some micro-chemical reactions, shows the wide application of silver nitrate in determining minerals in section. For the determination of silicates containing small quantities of chlorine, such as scapolite, it is convenient. The silver chloride produced is either allowed to darken by sunlight or reduced to metal by pyrogallous acid.

G. T. P.

A. Bergeat (*Min. Mitth.* xii. 263) gives a contribution to our knowledge of the massive rocks of Cyprus. They fall into two main groups—those which are to be ascribed to the pre-tertiary rocks of Zirkel, and those which from their contact phenomena are clearly recognised as of tertiary age. The first group consists of diorites, and the second of dioritic rocks, andesites, liparites, trachytes and tuffs. All the rocks, and especially the andesites, are much altered. The diorite forms the main mass of the Troodos Mountain, in the centre of the island, while the andesites are arranged in a broad zone around it. The liparites and trachytes were found on the north coast.

G. T. P.

The Felspar Rocks of Lake Superior.—Considerable tracts of Minnesota, on the Lake Superior coast, have been described as consisting of ' Labradorite rock ' or ' anorthite rock. ' These rocks, under the name of anorthosite, are now described by A. C. Lawson (*Bull. No. 8 of Geol. and Nat. Hist. Surv. Minn.* 1898). The felspar is found to vary from Labradorite (apparently the most usual) to anorthite. This makes up almost the whole of the rocks, which are of coarse texture, the crystals being frequently half an inch or more in diameter. The only original accessory mineral is a faint violet-brown augite in very subordinate quantity. This occurs not only as distinct grains and granular patches,

but also as interpositions in the felspar forming plates and rods parallel to definite crystallographic planes of the host. These resemble the "schiller" interpositions described by Judd, but are certainly original. An analysis of a labradorite rock gave the figures: SiO_2 47.40, Al_2O_3 29.74, FeO 1.94, CaO 13.80, MgO 0.57, Na_2O 4.99, K_2O 1.56, H_2O 1.64. Total 101.14; sp. gr. 2.704.

The rocks are regarded as a modification of gabbro, and as true plutonic rocks intruded among the Archæans before Palæozoic times. They are compared and tentatively correlated with the similar (Norian) rocks of Quebec, recently described by F. D. Adams.

A. H.

A new rock-type and rock-forming Mineral from California.—A. C. Lawson describes a peculiar group of lavas of post-Miocene age occurring at several places in the neighbourhood of Carmelo Bay, California (*Bull. Dep. Geol. Univ. Calif.* Vol. I. p. 1). In general characters and composition they range from andesite to basalt, but they are considered a group sufficiently distinct to receive a distinct name, *carmeloite*. Analyses by J. Posada are given of the more basic and the less basic type of the rock:—

SiO_2 ...	...	52.83	60.00
Al_2O_3 ...	...	17.67	19.01
Fe_2O_3 ...	...	7.50	3.20
FeO ...	...	1.68	0.68
CaO ...	...	7.35	1.04
MgO ...	...	2.47	1.28
K_2O ...	...	2.52	2.79
Na_2O ...	...	6.61	6.97
Ignition	...	2.32	4.30
		100.95	102.33
Sp. gr.	...	2.80	2.51 to 2.54

In texture the rocks vary from a holocrystalline variety to one with much glassy residue. Augite and plagioclase in varying proportions are among the porphyritic elements, but most characteristic is a mineral here named *iddingsite*. This is crystallographically rhombic, with elements resembling those of olivine. It has a highly perfect cleavage (100), hardness 2.5, sp. gr. up to 2.839; bronzy colour and lustre. Qualitative

sts make it a hydrous non-aluminous silicate of iron, lime, magnesia and soda. The optical orientation is

$$\alpha = a, \beta = b, \gamma = c.$$

In thin sections the colour is chestnut brown to citron yellow, with strong pleochroism: the refractive index is low, the birefringence high. The author inclines to the opinion that iddingsite is not a pseudomorph after olivine or any other mineral, but an original constituent. A. H.

Soda-rhyolite in California. C. Palache gives a description of a soda-rhyolite, probably of Tertiary age, occurring to the north of Berkeley (Bull. Dep. Geol. Univ. Calif. Vol. I. p. 61). Different parts of the lava exemplify different phases, from a simple glass, through microlitic and micro-spherulitic varieties, to a micro-granular porphyritic type. Quartz, orthoclase, and an acid plagioclase are the only essential minerals, and magnetite the only accessory, ferro-magnesian constituents being entirely wanting. There is considerable variation in chemical composition, and the author finds this to be connected with the texture of the rock, the more acid types being also the more crystalline. The specific gravity is, for this reason, lowest in the most basic varieties.

			Porphyritic.	Spherulitic.	Glassy.
SiO ₂	...	...	83.59	75.46	69.85
Al ₂ O ₃	...	...	5.42 [1]	18.18	18.84
Fe ₂ O ₃ (and FeO)	...	...	trace	0.91	0.73
CaO	...	...	3.44	0.95	0.87
MgO	...	...	trace	0.10	trace
K ₂ O	...	...	1.37	1.09	2.68
Na ₂ O	...	...	5.33	6.88	5.58
H ₂ O	...	...	0.76	0.93	6.15
			99.91	99.50	99.20
Sp. gr.	...	...	2.54	2.42	2.32

A. H.

Contact-Metamorphism in Saxony.—R. Beck has given an account of the metamorphism observed in the neighbourhood of various granitic and gneissic intrusions in the Elbthal district (*Tscherm. Min. Mitth.* 1893, p. 290). The district is remarkable for the variety of different rocks which come under the influence of metamorphism. In this respect it can be compared only with the aureole around the Shap granite, with

which it has many points in common. The lowest rocks affected are phyllites of metamorphism: (i.) "Fruchtschiefer" with unaltered matrix, (ii.) Fruchtschiefer with re-crystallised matrix, (iii.) schistose micaceous rocks, (iv.) andalusite micaceous rocks. The chief points noticed are the gradual disappearance of chlorite and increasing formation of brown mica and andalusite, re-crystallisation of the quartz with coarser grain, and production of what the author terms typical "contact-structure" in the rock. Some associated chlorite-gneisses are in like manner converted into biotite-gneisses, but these rocks are only summarily described. In the felspathic quartzites the chief changes are the re-crystallisation of the felspar, the production of biotite, and the setting up of the contact-structure.

The Silurian clay-slates, like the phyllites above mentioned, are transformed into spotted schists and then into "Hornfels," but here cordierite is uniformly produced instead of andalusite. The well-known "clay-slate-needles" of rutile are converted into larger grains of rutile, locally into brookite, which has an occurrence similar to that of anatase near the Shap granite. "Kieselschiefer" (kyanite, etc.) is converted into a graphitic quartzite, the quartz being re-crystallised in large grains and graphite occurring to the extent of 2 per cent. in the altered rock. Biotite, chiastolite and pyrrhotite are also produced. Greywackes in the Silurian are re-crystallised with the typical "contact-structure" biotite, muscovite, etc., being characteristic products. The calcareous rocks are interesting, pure limestones being converted into marble, impure ones losing their carbonic acid and passing into lime-silicate-rocks with augite, birefringent garnet, actinolite, epidote, zoisite, etc. (not wollastonite, idocrase or scapolite). In other places the metamorphism of the calcareous rocks has been accompanied by an impregnation with ore deposits.

The Silurians of the district also include diabase [andesite] lavas and tuffs. The metamorphism of these gives rise to a number of minerals, the amphibolisation of the pyroxene being, here as elsewhere, highly characteristic, while biotite, epidote, sphene, etc., occur as at Shap. Anthophyllite is another mineral observed.

The Devonian strata exhibit the metamorphism of greywackes and also of conglomerates. In these latter the metamorphosed pebbles always retain their form and their sharp outline in the metamorphosed matrix. There are also near the contact certain gneissose rocks rich in felspar and cordierite.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, April 18th, 1893.

MR. R. H. SCOTT, M.A., F.R.S., Past-President, in the Chair.

Dr. Eugen Hussak, Assistant-Geologist to the Commissao Geographica Geologica de S. Paulo, Brazil, was elected an Ordinary Member.

The resignation of Mr. J. Gorham was announced.

GENERAL MEETING.

Held in the Apartments of the Geological Society, April 18th, 1893.

MR. R. H. SCOTT, M.A., F.R.S., Past-President, in the Chair.

Fourteen Members and two visitors were present.

The following papers were read:—

1. On extinction-angles in cleavage-flakes: by Mr. Alfred Harker, M.A., F.G.S. (Page 239).

2. Chemical Analysis of Fergusonite, from Rakwana, Ceylon: by Mr. T. Prior, M.A. (Page 234).

3. Notes on the optical properties of the globules and spherulites of zirconium phosphate and some other salts: by Lieut.-Gen. C. A. McMahon, F.R.S. (Page 229).

4. On the occurrence of gold in veins, with remarks on the paragenetic minerals: by Mr. Henry Louis, A.R.S.M., F.G.S. (Page 241).

5. On the discovery of meteoric iron in the district of Nejed, Central Arabia: by Mr. L. Fletcher, M.A., F.R.S.

Specimens illustrative of his paper were exhibited by Lieut. Gen. McMahon.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, June 13th, 1893.

PROF. N. S. MASKELYNE, F.R.S., President, in the Chair.

Prof. Lewis, Mr. Pringle, Mr. Prior, and Mr. J. S. Thomson were elected for nomination to replace the four retiring Members of Council, Prof. Cole, Mr. Danby, Mr. Horne and Mr. Rutley.

GENERAL MEETING.

Held in the Apartments of the Geological Society, June 13th, 1893.

Prof. N. S. MASKELYNE, F.R.S., President, in the Chair.

Ten Members were present.

The following papers were read :—

1. Remarks on the Ruby and Sapphire Mines of Siam: by Mr. Henry Louis, A.R.S.M., F.G.S.

2. An account of some crystals of quartz from North Carolina: by Mr. H. A. Miers, M.A., F.C.S.

Specimens were exhibited by Mr. Louis; and a new form of goniometer for use with liquids, and some naturally etched crystals of quartz, were exhibited by Mr. Miers.

EXCERPT MINUTES OF COUNCIL MEETING.

Held in the Apartments of the Geological Society, October 24th, 1893.

Prof. N. S. MASKELYNE, F.R.S., President, in the Chair.

Reported that Mr. Rudler, as Treasurer, would in future take charge of the accounts and general financial business of the Society.

Resolved to place the Austrian Museum, Sydney, on the list of Institutions receiving presented copies of the Journal.

The draft Annual Report of Council, submitted by the Secretary, was amended and approved.

ANNIVERSARY MEETING.

Held in the Apartments of the Geological Society, October 24th, 1893.

Prof. N. S. MASKELYNE, F.R.S., President, in the Chair.

Fourteen Members and one visitor were present.

The following Report of Council for the Session 1892-3 was read the Secretary :—

CONTENTS OF No. 47.

	PAGE
Xanthoconite and Rittingerite, with remarks on the Red Silvers. By H. A. MIERS, M.A., F.G.S. With analyses by G. T. PRIOR, M.A.	185
On a discovery of "Oriental Ruby" and "Margarite" in the Province of Westland, New Zealand. By Professor G. H. F. ULRICH, F.G.S., of Dunedin University	217
Binnite from Imfeld in the Binnenthal. By C. O. TRECHMANN, Ph.D., F.G.S.....	220
Notes on the optical characters of the Globules and Spherulites of Lithium Phosphate and some other salts. By Lieutenant-General C. A. McMAHON, F.G.S. (With Plate V.)	229
Fergusonite from Ceylon. By G. T. PRIOR, M.A.....	284
Extinction-Angles in Cleavage-Flakes. By ALFRED HARKER, M.A., F.G.S.....	289
On the mode of occurrence of Gold. By HENRY LOUIS, A.R.S.M., F.I.C., F.G.S., Mem. Amer. Inst. Min. Eng., etc.	241
On the "Skin" of Agates. By Professor M. F. HEDDLE, F.R.S.E., and J. STUART THOMSON	248
Reviews	251
Abstracts	254